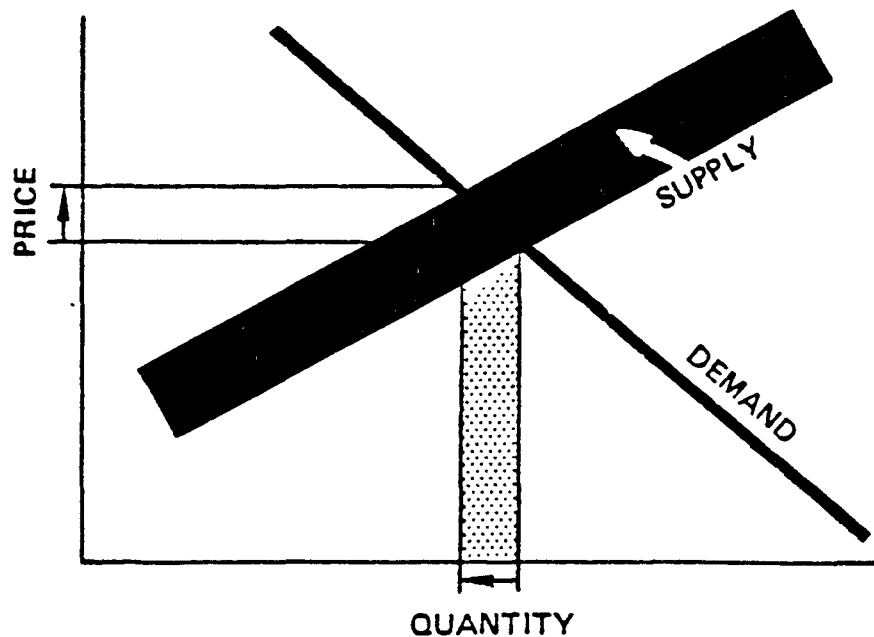




Economic Impact Analysis of Proposed Effluent Limitations and Standards for the Nonferrous Smelting and Refining Industry (Phase II)





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

This document is an economic impact assessment of the recently-proposed effluent guidelines. The report is being distributed to EPA Regional Offices and state pollution control agencies and directed to the staff responsible for writing industrial discharge permits. The report includes detailed information on the costs and economic impacts of various treatment technologies. It should be helpful to the permit writer in evaluating the economic impacts on an industrial facility that must comply with BAT limitations or water quality standards.

If you have any questions about this report, or if you would like additional information on the economic impact of the regulation, please contact the Economic Analysis Staff in the Office of Water Regulations and Standards at EPA Headquarters:

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Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of proposed effluent standards and limitations issued under Sections 301, 304, 306, and 307 of the Clean Water Act to the Nonferrous Metals Manufacturing Industry (Phase II).

The study supplements the technical study (EPA Development Document) supporting the issuance of these regulations. The Development Document surveys existing and potential waste treatment control methods and technologies within particular industrial source categories and supports certain standards and limitations based upon an analysis of the feasibility of these standards in accordance with the requirements of the Clean Water Act. Presented in the Development Document are the investment and operating costs associated with various control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the application of various control methods and technologies. This study investigates the impact on product price increases, the continued viability of affected plants, employment, and foreign trade.

This study has been prepared with the supervision and review of the Office of Water Regulations and Standards of EPA. This report was submitted in fulfillment of EPA Contract No. 68-01-6731 by Policy Planning & Evaluation, Inc. This analysis was completed in April 1984.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

A. PURPOSE

This study assesses the economic impacts likely to result from the effluent guidelines, limitations, and standards applicable to the nonferrous metals manufacturing industry. These regulations are based on Best Practicable Control Technology Currently Available (BPT), Best Available Technology Economically Achievable (BAT), New Source Performance Standards (NSPS), and Pretreatment Standards for New and Existing Sources (PSNS and PSES), which are being issued under authority of Sections 301, 304, 306, and 307 of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977. The economic impacts have been evaluated for specific regulatory options that correspond to varying levels of effluent controls. The approach consists of two parts:

- assessing the potential for plant closures; and
- determining the general industry-wide impacts, including changes in prices, employment, rates of return on investment, balance of trade, and small business impacts.

B. INDUSTRY COVERAGE

For purposes of this study, 24 nonferrous metal manufacturing subcategories are considered. These industries and the number of plants, by discharge status, covered by this regulation are listed in Table 1. Primary operations reduce metal ores to metal and metal products. Secondary operations convert scrap and waste to useful metal and metal products.

C. METHODOLOGY

The following paragraphs describe the steps followed in the analysis to evaluate the potential economic impacts of each regulatory option as of the effective date of compliance; the methodology has been consistently applied to all subcategories.

TABLE 1

SUMMARY OF NONFERROUS METAL SMELTING AND REFINING SUBCATEGORIES

Metal	Number of Plants			
	Direct	Indirect	Zero/Dry	Total
Primary Antimony	1	0	7	8
Bauxite Refining	4	0	4	8
Primary Beryllium	1	0	1	2
Primary Boron	0	0	2	2
Primary Cesium/Rubidium	0	0	1	1
Primary and Secondary Germanium/Gallium	0	1	4	5
Secondary Indium	0	1	0	1
Primary Lithium ^a				
Primary Magnesium ^a				
Secondary Mercury	0	0	4	4
Primary Molybdenum/Rhenium	4	0	9	13
Secondary Molybdenum/Vanadium	1	0	0	1
Primary Nickel/Cobalt	1	0	0	1
Secondary Nickel	0	1	1	2
Primary Precious Metals/Mercury	1	0	7	8
Secondary Precious Metals	3	29	16	48
Primary Rare-Earth Metals	1	1	2	4
Secondary Tantalum	3	0	0	3
Primary and Secondary Tin	3	2	7	12
Primary and Secondary Titanium	4	2	2	8
Secondary Tungsten/Cobalt	4	0	1	5
Secondary Uranium	1	0	2	3
Secondary Zinc ^a				
Primary Zirconium/Hafnium	<u>1</u>	<u>1</u>	<u>1</u>	<u>3</u>
Total	33	38	71	142

^aThese subcategories have been excluded from regulation and are not covered in the Economic Impact Analysis.

1. Description of the Industry

The first step in the analysis is to develop a description of the industry as it currently exists. The analysis of the current conditions addresses the following areas:

- technology;
- industry structure;
- demand for the metal products; and
- current trends in prices and capacity utilization.

This information forms the basis for conducting the financial tests and analyzing the potential for plant closures. Basic industry information was obtained from the Department of the Interior's Bureau of Mines, trade associations, and contacts with industry representatives.

2. Industry's Baseline Conditions

Plants subject to this regulation will be required to install the necessary control equipment by the effective date of compliance. It is expected that the current economic recovery will continue, even if at a slow pace, and that the general economic conditions during the impact period will be somewhat better than those in 1982, but not as good as those at the peak of 1978-1979. Since we expect normal conditions in the impact period, it is reasonable to assume that: (1) most plants will operate at less than full capacity (this implies that companies will not add new capacity to their operations); and (2) plants that survived the 1982 recession will be operating during the compliance period. Hence, this study assumes that the plant population and total capacity in an industry segment will remain the same as they were in 1982.

3. Costs of Compliance

The water treatment control systems, costs, and effluent limitations and pretreatment standards proposed for the nonferrous manufacturing industry are discussed in a separate document. Comprehensive descriptions of the methodology, the recommended technologies, and the estimated costs are provided in the Development Document for Effluent Limitations Guidelines and Standards for the Nonferrous Metals Point Source Category (Development Document). Several treatment and control options based on BPT, BAT, NSPS, PSES, and PSNS for facilities within the industry are considered. The engineering estimates of costs for the pollution control options are used to form the basis for the economic impact analysis.

4. Plant Closure Analysis

It is assumed that plants incurring small compliance costs will not be forced to close. Therefore, the closure analysis is conducted in two steps. First, a screening analysis is conducted to identify plants that clearly will not be affected by this regulation. Second, a net present value test and a liquidity test are carried out for those plants that fail the screen.

a. Screening Analysis

Total annual compliance cost as a percentage of annual revenues is used as the screening criterion. The threshold value chosen for the screen is 1.0%. If compliance costs for the plant are less than 1.0% of plant revenues, the plant is not considered highly affected, and is not analyzed further.

b. Closure Analysis

Pollution control expenditures will result in reduction of income when costs cannot be passed through. These expenditures may create a permanent change in income levels and thereby reduce average income in the future. The expenditures may also adversely affect a plant's short-term cash flow. The consideration of cash flow becomes important when a plant is already in poor financial health. These long-term and short-term effects of pollution control expenditures are analyzed by conducting a net present value (NPV) test and a liquidity test. The NPV test is used to determine the long-term viability of a plant; the liquidity test addresses potential short-term cash flow problems.

5. Other Impacts

In addition to closures, other industry-wide impacts are assessed. These include:

- increase in cost of production;
- price change (note that this varies from the closure analysis which assumes that costs may not be recovered through increased prices);
- change in return on investment;
- capital compliance costs compared to annual capital expenditures (capital impacts);

- employment impacts; and
- foreign trade impacts.

In addition, a separate analysis is performed to determine whether small businesses will be significantly affected by the imposition of compliance costs.

D. BASIS FOR COMPLIANCE COSTS

Brief descriptions of the various treatment options are listed below. These descriptions do not necessarily correspond to the specific options considered for a particular subcategory. A complete description of the options can be found in the Development Document.

- Option A - End-of-pipe treatment consisting of chemical precipitation and sedimentation, and preliminary treatment, where necessary, consisting of oil skimming, cyanide precipitation, and ammonia steam stripping. This combination of technology reduces toxic metals, conventional and nonconventional pollutants.
- Option B - Option B is equal to Option A preceded by flow reduction of process wastewater through the use of cooling towers for contact cooling water and holding tanks for all other process wastewater subject to recycle.
- Option C - Option C is equal to Option B plus end-of-pipe polishing filtration for further reduction of toxic metals and TSS.
- Option E - Option E consists of Option C plus activated carbon adsorption applied to the total plant discharge as a polishing step to reduce toxic organic concentrations.
- Option G - Option G consists of chemical oxidation applied to the total plant discharge, as a step to reduce toxic organic concentrations, without any other end-of-pipe treatment or pretreatment.

For three subcategories, Primary and Secondary Germanium/Gallium, Primary and Secondary Titanium, and Primary Zirconium/Hafnium, two levels of limitation have been proposed. The costs estimated for each subcategory are presented in Table 2. Costs were calculated for each plant based on production, wastewater flows, and treatment in place. All costs are in 1982 dollars. Investment costs in Table 2 represent the total capital necessary to construct the treatment facilities. Total annual costs are comprised of annual operating and maintenance costs plus the annualized portion of the investment costs.

TABLE 2

NONFERROUS SMELTING AND REFINING INDUSTRY -- COMPLIANCE COST ESTIMATES
(1982 dollars)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary Antimony									
Direct	1	36,634	13,698	36,634	13,698	44,137	16,767		
Indirect	0	0	0	0	0	0	0		
Total	1	36,634	13,698	36,634	13,698	44,137	16,767		
Bauxite Refining ^a									
Direct	4							8,290,029	2,103,682
Indirect	0							0	0
Total	4							8,290,029	2,103,682
Primary Beryllium									
Direct	1			W	W	W	W	W	W
Indirect	0			0	0	0	0	0	0
Total	1			W	W	W	W	W	W
Primary and Secondary Germanium/Gallium									
Direct	0	0	0	0	0	0	0	0	0
Indirect	1	W	W	W	W	W	W	W	W
Total	1	W	W	W	W	W	W	W	W
Secondary Indium									
Direct	0	0	0	0	0	0	0	0	0
Indirect	1	W	W	W	W	W	W	W	W
Total	1	W	W	W	W	W	W	W	W
Primary Molybdenum/Rhenium									
Direct	4	208,551	338,499	208,551	338,449	347,313	414,072		
Indirect	0	0	0	0	0	0	0		
Total	4	208,551	338,499	208,551	338,449	347,313	414,072		
Secondary Molybdenum/Vanadium									
Direct	1	W	W	W	W	W	W	W	W
Indirect	0	0	0	0	0	0	0	0	0
Total	1	W	W	W	W	W	W	W	W

(Continued)

TABLE 2 (Continued)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary Nickel/Cobalt									
Direct	1	W	W	W	W	W	W	W	W
Indirect	0	0	0	0	0	0	0	0	0
Total	1	W	W	W	W	W	W	W	W
Secondary Nickel									
Direct	0	0	0	0	0	0	0	0	0
Indirect	1	W	W	W	W	W	W	W	W
Total	1	W	W	W	W	W	W	W	W
Primary Precious Metals/ Mercury									
Direct	1	27,500	8,610	27,500	8,610	29,975	9,755	29,975	9,755
Indirect	0	0	0	0	0	0	0	0	0
Total	1	27,500	8,610	27,500	8,610	29,975	9,755	29,975	9,755
Secondary Precious Metals									
Direct	3	299,535	240,155	299,535	242,505	306,846	251,434	306,846	251,434
Indirect	29	1,731,246	856,333	1,736,619	866,895	1,844,518	916,476	1,844,518	916,476
Total	32	2,030,781	1,096,488	2,036,154	1,109,400	2,151,364	1,167,910	2,151,364	1,167,910
Primary Rare-Earth Metals									
Direct	1	W	W	W	W	W	W	W	W
Indirect	1	W	W	W	W	W	W	W	W
Total	2	W	W	W	W	W	W	W	W
Secondary Tantalum									
Direct	3	7,270	44,708	7,270	44,708	15,437	48,962	15,437	48,962
Indirect	0	0	0	0	0	0	0	0	0
Total	3	7,270	44,708	7,270	44,708	15,437	48,962	15,437	48,962
Primary and Secondary Tin									
Direct	3	829,757	348,124	829,757	348,124	938,773	381,108	938,773	381,108
Indirect	2	W	W	W	W	W	W	W	W
Total	5	W	W	W	W	W	W	W	W

(Continued)

TABLE 2 (Continued)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary and Secondary Titanium									
Direct	4	1,224,289	519,237	1,225,075	519,898	1,334,834	558,753		
Indirect	2	W	W	W	W	W	W		
Total	6	W	W	W	W	W	W		
Secondary Tungsten/Cobalt									
Direct	4	93,912	272,620	103,165	283,711	135,148	295,353		
Indirect	0	0	0	0	0	0	0		
Total	4	93,912	272,620	103,165	283,711	135,148	295,353		
Secondary Uranium									
Direct	1	28,600	49,301	28,600	49,301	54,313	58,379		
Indirect	0	0	0	0	0	0	0		
Total	1	28,600	49,301	28,600	49,301	54,313	58,379		
Primary Zirconium/Hafnium									
Direct	1	W	W	W	W	W	W		
Indirect	1	W	W	W	W	W	W		
Total	2	W	W	W	W	W	W		
Total Direct	33	3,670,516	2,958,317	3,689,630	2,974,588	4,241,416	3,207,845	W	W
Total Indirect	38	2,567,861	1,142,945	2,618,689	1,158,836	2,860,324	1,263,233	W	W
Industry Total ^b	71	6,238,377	4,101,262	6,308,319	4,133,424	7,101,740	4,471,078	W	W

^aThe Agency is presently proposing only technical amendments to existing Bauxite regulations; however, it is considering toxic limitations on the net precipitation discharges from Bauxite red mud impoundments. The Bauxite numbers in this table and elsewhere in this document refer to the toxic limitations under consideration by the Agency.

^bThis figure represents the total compliance cost that would be incurred by the industry at each option. Some treatment levels are not viable options in certain subcategories. Total compliance costs for Option E include compliance costs for Option C plus incremental costs for Option E.

W -- Withheld to avoid disclosing company proprietary data.

E. FINDINGS

1. Plant Closure Analysis

The overall results of the plant closure analysis are presented in Table 3. Plant and production line closures have been identified in the Primary and Secondary Tin, and Secondary Precious Metals subcategories.

2. Other Impacts

a. Increase in Cost of Production

The increase in cost of production resulting from an increase in compliance costs, for both direct and indirect dischargers in the nonferrous manufacturing industry, is summarized in Table 4. The results show that most of the plants experience a minimal (less than 2%) increase in the cost of production. Of the 38 indirect dischargers in the whole industry, five plants at Option C are expected to incur more than a 2% increase in production cost. Most direct dischargers are expected to incur insignificant cost increases.

b. Price Change

The change in price under the assumption of full pass-through of costs is closely linked to the increase in the cost of production. The results of price increase are, therefore, quite similar to the results of increased production costs. Table 4 shows that the price increase is insignificant under each option for most plants even if all costs are passed on to the consumers. It should be noted that the assumption of full cost pass-through was not used in the screening or closure analyses.

c. Change in Return on Investment

The return on investment is a good measure of a firm's profitability. The control costs of this regulation cause less than a 10% decrease in the profitability of most of the firms that have been analyzed; approximately 80% of both direct and indirect dischargers are thus not affected significantly. Only a few firms experience decreases in the 10%-20% range. The majority of these plants experiencing a decrease in ROI of more than 20% are identified as potential closures. These results are shown in Table 4.

TABLE 3

SUMMARY OF POTENTIAL CLOSURES

Subcategory	Plants Incurring Costs		Plants Failing Screen		Potential Plant and Line Closures		Potential Employment Loss
	Direct	Indirect	Direct	Indirect	Direct	Indirect	
Primary and Secondary Tin							
Option A	3	2	2	2	2	2	43
Option B	3	2	2	2	2	2	43
Option C	3	2	2	2	2	2	43
Secondary Precious Metals							
Option A	3	29	0	1	0	1	4
Option B	3	29	0	1	0	1	4
Option C	3	29	0	1	0	1	4

TABLE 4

SUMMARY OF OTHER IMPACTS
(number of plants)

	Plants Incurring Costs	Plants Failing Screen	Average % Change in Return on Investment			Average % Increase in Production Cost		Average % Price Change		Average Investment Cost as a % of Capital Expenditure		
			0-10%	10-20%	20%	0-2%	2%	0-2%	2%	0-10%	10-20%	20%
Direct Dischargers	27	6	21	4	2	23	4	23	4	20	4	3
	18	3	15	3	0	15	3	16	2	14	3	1
	28	7	21	5	2	23	5	24	4	18	7	3
	5	0	4	1	0	5	0	5	0	3	1	1
Indirect Dischargers	37	6	31	1	5	33	4	33	4	13	7	17
	32	2	29	1	2	30	2	30	2	12	6	14
	38	8	31	2	5	33	5	34	4	12	5	21
	1	0	1	0	0	1	0	1	0	1	0	0

d. Average Investment Cost as a Percentage of Capital Expenditures

The additional investment cost required to comply with the effluent guidelines has been studied in relation to the annual capital expenditures of the plants. Of the 38 indirect dischargers in the industry, 21 producers under Option C are expected to commit at least 20% of their average capital expenditures to the new investment cost. For most of the remaining firms, investment costs are less than 10% of the average capital expenditures. A majority of the direct dischargers fall into this category. Details under each option are presented in Table 4.

e. Employment Impacts

The employment impacts of the regulatory costs have been examined in the context of plant closures. Potential plant and line closures have been identified in the Primary and Secondary Tin and Secondary Precious Metals subcategories (see Table 3). These closures could cause an employment loss of about 47 workers. The remaining subcategories are not impacted sufficiently to cause plant closures. Given the low price and production effects in these subcategories, employment effects are expected to be minimal. Minor production decreases could be brought about by shifts in capacity utilization rather than loss of capacity.

f. Foreign Trade Impacts

The foreign trade impacts are analyzed with respect to the effect of regulatory costs on the balance of trade. The closure of high-impact plants could result in a loss of capacity of over 650 short tons. However, the impact could be minimized if other plants increase their production levels. To the extent that the existing or new plants make up for the lost capacity, the balance of trade will not be adversely impacted.

3. Small Business Impacts

Small business impacts are analyzed using two tests: (1) total annual compliance costs as a percentage of total revenues; and (2) compliance investment cost as a percentage of average capital expenditures. The results of the tests show that small businesses will not be significantly impacted by this regulation. These results and the definitions used for classification of small businesses are found in Chapter XXIV. Table 5 highlights the results of the closure analysis as it pertains to small businesses.

TABLE 5

RESULTS OF CLOSURE ANALYSIS FOR SMALL BUSINESSES

Industry Subcategory	Number of Plants Incurring Costs	Number of Small Plants Incurring Costs	Number of Small Plants/ Production Lines Projected to Close
Primary and Secondary Tin	5	3	3
Primary and Secondary Titanium	6	1	0
Primary Zirconium/Hafnium	2	1	0
Secondary Precious Metals	32	8	1
Secondary Tungsten/Cobalt	4	1	0

4. New Source Impacts

The basis for new source performance standards (NSPS) and pretreatment standards for new sources (PSNS) as established under Section 306 of the Clean Water Act is the best available demonstrated technology. For regulatory purposes new sources include greenfield plants and major modifications to existing plants.

In evaluating the potential economic impact of the NSPS/PSNS regulations on new sources, it is necessary to consider the costs of the regulations relative to the costs incurred by existing sources under the BAT/PSES regulations.

The Agency has determined that the new source regulations for most subcategories are not more costly than those for existing sources. The technology basis of the new source regulations is the same as for BAT. Since there is no incremental cost associated with the technology, new sources will not be operating at a cost disadvantage relative to existing sources due to the regulations.

For those subcategories for which new source limitations are based on a more costly technology or there are no existing discharging sources, it has been determined that the incremental costs are not sufficient to cause barriers to entry for new sources.

CHAPTER I

ECONOMIC IMPACT ANALYSIS METHODOLOGY

I. ECONOMIC IMPACT ANALYSIS METHODOLOGY

A. OVERVIEW

This section describes the analytical approach to estimate the economic impacts of effluent guidelines controls on the nonferrous metals manufacturing industry. The nonferrous metals manufacturing category includes plants that produce primary metals from ore concentrates and plants that recover secondary metals from recycled metallic wastes. For regulatory purposes, the category is divided into two separate segments. This report covers the Phase II segment, which consists of 24 subcategories:

- | | |
|--|---------------------------------------|
| • Primary Antimony | • Primary Nickel/Cobalt |
| • Bauxite Refining | • Secondary Nickel |
| • Primary Beryllium | • Primary Precious Metals/
Mercury |
| • Primary Boron | • Secondary Precious Metals |
| • Primary Cesium/Rubidium | • Primary Rare-Earth Metals |
| • Primary and Secondary
Germanium/Gallium | • Secondary Tantalum |
| • Secondary Indium | • Primary and Secondary Tin |
| • Primary Lithium | • Primary and Secondary
Titanium |
| • Primary Magnesium | • Secondary Tungsten/Cobalt |
| • Secondary Mercury | • Secondary Uranium |
| • Primary Molybdenum/Rhenium | • Secondary Zinc |
| • Secondary Molybdenum/
Vanadium | • Primary Zirconium/Hafnium |

The Agency is proposing to completely exclude three of these subcategories (Secondary Zinc, Primary Lithium, and Primary Magnesium) from regulations because the plants in these subcategories are at zero discharge and new facilities are not expected. The economic impacts on the remaining 21 metal subcategories have been evaluated for specific regulatory options that correspond to varying levels of effluent controls. The general approach consists of two parts:

- assessing the potential for plant closures; and
- determining the general industry-wide impacts, including changes in prices, employment, rates of return on investment, balance of trade, and small business impacts.

The assessment of plant closures is made by using two financial analysis tests: (1) a net present value (NPV) test, and (2) a liquidity test. The NPV test evaluates the impact of pollution controls on the long-term viability of a plant; the liquidity test measures the short-term solvency.

Production and capacity utilization behavior of the industry between 1978-1982 form the basis of assumptions used in the analysis. The approach also considers updated information on industry conditions

obtained from industry and government sources. The approach proceeds with the following steps:

- 1) description of the industry structure:
 - raw materials and production processes
 - description of plants
 - U.S. production, consumption, and trade
 - end uses and substitutes;
- 2) trends in prices and capacity utilizations and consideration of baseline population;
- 3) calculation of annual compliance costs;
- 4) assessment of plant closures;
- 5) determination of industry-wide impacts;
- 6) new source impacts; and
- 7) small business analysis.

Each of these steps is described below to provide a broad framework for the analysis. The details of the calculations, including associated equations, are given in four appendices. The broad framework is designed to allow the reader to read and understand the basic methodology quickly. The appendices provide details on the methods used to implement the NPV and the liquidity equations.

The major sources of data used in this study are listed below:

- U.S. Environmental Protection Agency: EPA industry surveys conducted in 1982 under Section 308 of the Clean Water Act. Of particular importance are data on products produced, production volume, value of regulated products, value of plant shipments, capacity utilization, total employment, and employment in the regulated sector.
- U.S. Department of Commerce: Census of Manufacturers, U.S. Industrial Outlook, Quarterly Financial Report for Manufacturing, Mining and Trade Corporations.
- U.S. Department of the Interior: Mineral Industry Surveys, Mineral Facts and Problems, Minerals and Materials, Mineral Commodity Summaries, and Mineral Industry Profiles.
- Trade and business publications: American Metal Market and Modern Metals.
- Interviews with trade association and industry personnel.

- o Annual and 10-K reports of companies engaged in mining, smelting, and refining nonferrous metals.

In some instances, these sources indicate that the Agency may have underestimated the number of plants in a subcategory. We solicit information or comment on any plant not covered in the analysis.

B. STEP 1: DESCRIPTION OF INDUSTRY STRUCTURE

1. Raw Materials and Production Processes

Nonferrous metals are produced in a series of steps that may include smelting, refining, alloying, and producing metallic chemicals. Some of these steps are covered by existing regulations (such as effluent guidelines for inorganic chemicals manufacturing). The purposes of this section are to describe the production technology in simple terms and indicate the steps involved in producing metal and metal products from ore as well as from recovered materials (scrap), and to identify the stages covered by this regulation. This information is used to provide relevant information regarding the industry structure and to classify plants into various categories.

2. Description of Plants

Plants have been classified on the basis of: (1) raw material, (2) outputs, and (3) the use of outputs. Some plants use ore; others use recycled materials; and others use byproduct ores. A few plants produce metals; others produce formed product and metallic chemicals. Some plants use the output captively, while others sell products to outside companies.

The descriptions of plants, along with the structure of the companies that own the plants, are used to analyze the effects of the regulations in terms of potential plant closures. For most of the metals covered in this analysis, the following types of producers exist: (1) large integrated companies that produce metals from ore from their own mines; (2) integrated metals producers who also produce final products; (3) independent firms; and (4) recyclers and smelters. The characteristics of each type of manufacturer are also taken into account in analyzing the economic effects.

For purposes of conducting the two financial tests, each plant is first placed into one of eight business groups. Business segment information given in financial reports of almost 30 metals companies forms the data base for this classification. Two broad criteria -- type of metal and type of manufacturing processes -- have been used to form the groups. For example, primary production is separated from secondary

production. The secondary production is divided into two groups: reclamation of precious metals and reclamation of non-precious metals. Primary production is divided into six groups based on metal types. Analysis of the financial data shows that significant differences in financial characteristics exist among groups. For details see Appendix B. After a plant has been classified into a group it is evaluated by using the financial characteristics of the group and plant-specific information.

This analysis uses business segment information rather than corporate income information. This is because the business segments of a corporation can be associated closely with the operations of a plant. A corporation, especially a large one, is often an amalgam of diverse businesses, and corporate ratios based on corporate financial data may not have much relevance to the financial performance of its business segments. For this reason, business segment information is used to the extent possible. However, the business segment information does not contain data on taxes and current assets. Thus, corporate taxes and current assets must be allocated to business segments. This procedure is described in Appendix B.

3. U.S. Production, Consumption and Trade

Time series data on production, consumption, and trade are used to discuss the importance of imports, the relationship between secondary and primary production, and changes in the basic structure of the industry. For many of these metals, imports of either raw material or finished metals constitute a significant part of total production. Further, secondary metal industry production forms a large part of total production. High regulatory compliance costs can have significant effects on the future income of domestic producers if imports are a large part of total consumption. Similarly, secondary metal producers may find themselves at a competitive disadvantage if their compliance costs are disproportionately high.

4. End Uses and Substitutes

Changes in major end use markets of a metal cause long-term structural changes in its demand. Such structural changes are likely to affect the long-term profitability (and hence economic viability) of existing plants. This section in each chapter discusses the historical trends in the size of each major end-use market and assesses the impacts of the trends on overall demand.

C. STEP 2: TRENDS IN PRICES AND CAPACITY UTILIZATION AND CONSIDERATION OF BASELINE POPULATION

Prices of metals and metal products depend to a large extent on final demand. When the demand is high, an industry operates its plants at a relatively high capacity, the prices are high, and operating income

is also high. On the other hand, when demand is low, capacity, prices, and income are generally low. The trends in capacity utilization and prices, in general, parallel the trends in general economic conditions. In this study, the trends over the five-year period between 1978-1982 were used to help determine economic impacts.

In order to estimate the effects of regulations, a methodology usually requires yearly projections of product prices, number of plants, and total production at the estimated time of compliance. However, as discussed below the methodology used for this analysis avoids the need for such projections. The analysis in this report uses the NPV and the liquidity tests to determine potential plant closures. The NPV test uses long-term "constant" income for the analysis. For purposes of this report, this income is taken to be the average of operating income between 1978-1982. This period is considered representative because it covers a complete business cycle; the peak in production occurred during the early years and the trough took place in 1982. Hence, averages of prices and capacity utilization during this period, used to calculate income of plants, will provide reasonable estimates of constant income.

The liquidity test evaluates the short-term viability of plants by examining their cash flows. The short-term period over which financial conditions are tested is five years. Since constant income estimates are used to conduct the test, price and production forecasts are not required.

During the 1982 recession, the capacity utilization in most of the nonferrous industries was extremely low. It was accompanied by a high level of inventories and a low level of profits. In fact, many plants were unprofitable during 1982. However, the plants that have survived the 1982 recession are now operating at higher capacity utilization levels and in many cases have started earning profits again. It is expected that the economic recovery will continue, even if at a slow pace, and that the general economic conditions during the compliance period will be somewhat better than those in 1982, but probably not as good as those at the peak of 1978-1979. Therefore, it is reasonable to assume that: (1) most plants will operate at less than full capacity (this implies that companies will not add new capacity to their operations); and (2) plants that survived the 1982 recession will be operating during the compliance period. Hence, this study assumes that the plant population and the total capacity in an industry segment will remain the same as they were in 1982.

D. STEP 3: COMPLIANCE COST ESTIMATES

Pollution control technologies result in two types of compliance costs: (1) capital costs for the control equipment, and (2) annual costs for operation and maintenance. Compliance costs are based on engineering estimates of specific treatment alternatives and were

developed for each plant after accounting for wastewater treatment already in place. Descriptions of the costing procedures and treatment alternatives are presented in the Development Document. These costs are used in this report to determine economic impacts. The increased costs have the following effects on the capital structure of a plant: (1) increased tax benefits due to investment tax credits and greater depreciation; (2) reduced overall taxes due to additional operating and maintenance costs; (3) increased asset base; and (4) increased overall production costs. These costs and benefits can be converted to total annual costs of controls as follows.

- The net present value of the tax benefits due to depreciation, which occur over the depreciable life of the equipment, is calculated.
- Tax benefits due to depreciation and investment tax credits are subtracted to obtain effective capital costs.
- Effective capital costs are amortized over the useful life of the assets to obtain annualized capital costs.
- Total annual costs are calculated by adding the annualized capital costs and annual operating and maintenance costs after taking into account tax effects of increased operating and maintenance costs.

Estimated compliance costs for this regulation are based on 1982 production levels (flow rates) as explained in the Development Document. For those subcategories where operating conditions in the impact period are expected to be an improvement over those experienced in 1982, compliance costs have been increased to account for higher flow rates. The factor by which costs are adjusted is the ratio of expected production at the time of compliance (based on average capacity utilization from 1978 to 1982) to actual (1982) production levels.

The detailed procedures for calculating annual costs are given in Appendix C. Plant-specific costs and cost adjustment factors are included in the confidential record of this proposed rulemaking.

E. STEP 4: PLANT-LEVEL ECONOMIC IMPACTS

Pollution controls affect plants in different ways. Some plants bear relatively high costs in order to comply with the regulations; others incur much smaller costs. It is reasonable to assume that the plants incurring relatively small costs will not close as a result of the regulations. Therefore, the analysis is conducted in two steps. First, a screening analysis is conducted to identify plants that will not be seriously affected by the regulations. Second, the NPV and the liquidity tests are carried out to determine whether plants that fail the screen will close. The screen and the two closure tests are discussed below.

1. Description of Screening Analysis

Total annual costs as a percent of annual revenues is used as the screening criterion. The threshold value chosen for the screen is 1.0%, that is, if the compliance costs for a plant are less than 1.0% of the revenues, it is not considered to be highly affected, and is not analyzed further.

The screening analysis is conducted for each plant expected to incur compliance costs. Total annual costs are calculated by adding the amortized portion of capital costs to the annual operating and maintenance costs. Annual revenues are calculated by multiplying the price of the product by estimated production of the plant. Price values for each product are generally based on an average of 1978-1982 prices for the metal product. The specific values and their sources are presented in each chapter.

The production level for a plant is estimated by multiplying plant capacity by a subcategory capacity utilization rate. Plant capacity data were generally available from public sources. The capacity utilization rate is based on an average of 1978-1982 values for each subcategory. The subcategory rates used in the analysis are identified in each chapter.

2. Discussion of Plant Closure Tests

Pollution control expenditures result in a reduction of income (when costs cannot be passed through). These expenditures may create a permanent change in income levels and thereby reduce average income in the future. The expenditures may also adversely affect a plant's short-term cash flow. The consideration of cash flow becomes important when a plant is already in poor financial health. It should be expected that such a plant will have to finance the pollution control expenditures through a bank and that the bank will not lend money for a period longer than five years -- the depreciable life of the asset for tax purposes. Negative cash flows may be created by principal and interest payments; however, there will also be positive cash flow due to tax benefits. These long-term and short-term effects of pollution control expenditures are analyzed by conducting the net present value (NPV) test and the liquidity test. The NPV test is used to determine the long-term viability of a plant; the liquidity test addresses potential short-term cash flow problems.

a. Net Present Value Test

The net present value test is based on the assumption that a company will continue to operate a plant if cash flow from future operations is expected to exceed its current liquidation value. This assumption can be written mathematically as follows:

$$\sum_{t=1}^T U_t \left(\frac{1}{1+r}\right)^t + L_T \left(\frac{1}{1+r}\right)^T \geq L_0$$

Where: U_t = cash flow in year t =
 earning before interest but after taxes (EBIAT) =
 revenues - all operating expenses including depreciation at book value - taxes

L_0 = current liquidation value

L_T = terminal liquidation value, i.e., liquidation value at the end of the planning horizon of T years

r = cost of capital.

In order to use this formula in this form, forecasts of the terminal liquidation value and earnings (U_t) in every year during the planning period (T) have to be made. However, the equation shown above can be simplified (and the need to make forecasts avoided) by making several assumptions. The simplified formula and the assumptions are given in Appendix A. The NPV test, after simplification and consideration of annual costs (see Appendix C), can be written as follows:

If,
$$\frac{\bar{U} - APC_p}{\bar{L}_0} \geq \bar{r},$$

then the plant will stay in operation.

Where: \bar{U} , \bar{L}_0 , and \bar{r} are, respectively, real earnings, real liquidation value, and real cost of capital (definitions of these variables are given in Appendix A); and

APC_p = total annual costs as given in Appendix C.

This equation states that if the rate of return on the liquidation value \bar{U}/\bar{L}_0 is greater than or equal to the real after-tax rate of return on assets (which corresponds to \bar{r}), then the plant will continue in operation.

This test is carried out for every plant that fails the screen -- that is, where total annual costs are greater than 1 percent of revenues. In order to conduct the test, each plant is first classified into one of the eight groups discussed in Appendix B.

Then, \bar{U} and \bar{L}_0 are calculated (for each plant) by using various group ratios. The Q total annual costs are subtracted from real earnings (\bar{U}), and the ratio $(\bar{U} - APC_p)/\bar{L}_0$ is compared with the groups' cost of capital (r).

By subtracting the appropriate compliance cost (APC_p), the NPV test implicitly assumes that increased costs will not be passed through to consumers. This assumption avoids overlooking potential impacts by incorporating the full effect of the costs on a plant's earnings.

b. The Liquidity Test

The basic premise of this test is that a plant will close if pollution control expenditures result in net negative cash flows in the foreseeable future. It is assumed that pollution control equipment will be financed over five years; the associated total annual costs represent cash outflows. The test can be stated in simple terms as follows (see Appendix C for details):

If

$$\bar{U} - APC_q < 0,$$

then the plant will close.

Where: \bar{U} = real earnings (as defined above)

APC_q = total annual costs for the liquidity test (see Appendix C; note that there is a difference between APC_p and APC_q .)

The treatment of cost pass-through for the liquidity test is the same as for the NPV test; the full compliance cost is assumed to be absorbed by the plant and is subtracted from the plant's earnings.

c. Interpretation of Plant Closure Tests

A potential plant closure is projected if either of the two tests is failed. The identification of plants as potential closures in this step is interpreted as an indication of the extent of plant impact rather than as a prediction of certain closure. The decision by a company to close a plant also involves other considerations, such as non-competitive markets for products, degree of integration of operation, use of output of plants as intermediate products (captive markets), and existence of specialty markets. Most of these factors can only be evaluated qualitatively and are taken into account only after the quantitative results of the two financial tests have been obtained.

For some of the facilities included in this study, production of the relevant nonferrous metal represents only a limited portion of total production capacity at the plant. If the closure tests are failed by a plant meeting this description, the analysis suggests it would be unprofitable for the plant to continue operations for the metal associated with the compliance cost. In this case, the effect is identified as a production line closure. It is not reasonable to extend this conclusion to the entire production facility because the compliance costs, sales, and plant closure tests are all based on production of the one metal.

F. STEP 5: INDUSTRY-WIDE IMPACTS

As compared to the plant-level closure analysis, this step focuses on impacts that are likely to occur at an industry-wide level. These impacts include effects on: (1) cost of production; (2) prices; (3) return on investment; (4) capital expenditures; (5) employment and communities where plants and their suppliers are located; and (6) balance of trade.

Each of these impacts is calculated for each subcategory, and the results are presented in Chapter XXII. The calculations rely on both group ratios and plant-specific information. The equations used to calculate the impacts are shown in Appendix D.

1. Changes in the Cost of Production

The financial impact of the regulatory alternatives on each industry is evaluated in terms of the increase to cost of production. This impact is measured by calculating the ratio of total annual compliance cost to total production cost, where production costs are calculated as plant revenues less operating income. This ratio represents the percentage increase in operating costs due to compliance expenditures.

2. Price Changes

The price change is the ratio of total annual compliance cost to annual plant revenue. This ratio represents the maximum percentage increase in price that would be required to maintain pre-compliance income levels. It is calculated with the assumption of full pass-through of costs. This assumption of full pass-through is not used in the closure analysis, but only in the calculation of price changes.

3. Changes in Return on Investment

Return on investment is calculated before and after the imposition of compliance costs. The return on investment before compliance costs is the value \bar{r} , which is computed for each group. The return on investment after compliance costs accounts for the effect of these costs on both income and assets. Annual compliance costs act to reduce income, while capital costs increase the asset base. A percentage change in return on investment is then derived from the two values. The change in return on investment represents the change in earnings per dollar of assets that is expected to result under each treatment option.

4. Effects on Capital Expenditures

This impact compares the capital compliance cost to expected capital expenditures. This ratio represents the percentage of additional capital expenditure needed to comply with each treatment option while maintaining previous investment programs.

5. Employment Impacts

Employment impacts are measured by the total number of jobs lost at plants expected to close. Employment estimates for production facilities projected to close are based on individual plant production data obtained from the Agency's survey of the industry and an estimate of production per employee.

6. Effects on the Balance of Trade

The economic impact of this regulation on foreign trade is the combined effect of price pressure from higher costs and production loss due to potential plant closure. The impact on foreign trade is discussed in the context of these two effects.

G. STEP 6: NEW SOURCE IMPACTS

New facilities and existing facilities that undergo major modifications are subject to NSPS/PSNS guidelines. Compliance costs of new source standards have been defined as incremental costs over the costs of selected standards for existing sources. The purpose of this approach is to determine if control costs constitute significant barriers to the entry of new sources into the industry.

H. STEP 7: SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354) requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. In this study, an initial screening analysis is performed to determine if a substantial number of small entities will be significantly affected. This step identifies the economic impacts likely to result from the promulgation of regulations on small businesses. The primary economic variables that are covered are those that are analyzed in the general economic impact analysis, including compliance costs, plant financial performance, plant closures, and unemployment. Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis which is described above.

CHAPTER II

EFFLUENT GUIDELINE CONTROL OPTIONS AND COSTS

II. EFFLUENT GUIDELINE CONTROL OPTIONS AND COSTS

The alternative water treatment control systems, costs, and effluent limitations for the nonferrous manufacturing industry are enumerated in the Development Document. The Development Document also identifies various characteristics of the industry, including manufacturing processes; products manufactured; volume of output; raw waste characteristics; supply, volume, and discharge destination of water used in the production processes; sources of waste and wastewaters; and the constituents of wastewaters. Using these data, pollutant parameters requiring limitations or standards of performance were selected by EPA.

The EPA Development Document also identifies and assesses the range of control and treatment technologies for the industry. These technologies are evaluated for existing surface water industrial dischargers to determine the effluent limitations required for the Best Practicable Control Technology Currently Available (BPT), and the Best Available Technology Economically Achievable (BAT). Existing and new dischargers to Publicly Owned Treatment Works (POTWs) are required to comply with Pretreatment Standards for New Sources (PSNS), and new direct dischargers are required to comply with New Source Performance Standards (NSPS), which require Best Available Demonstrated Control Technology (BDT). The identified technologies are analyzed to calculate cost above treatment in place and performance.

Brief descriptions of the various treatment options are listed below. These descriptions do not necessarily correspond to the specific options considered for a particular subcategory. A complete description of the options can be found in the Development Document.

- Option A - End-of-pipe treatment consisting of chemical precipitation and sedimentation, and preliminary treatment, where necessary, consisting of oil skimming, cyanide precipitation, and ammonia steam stripping. This combination of technology reduces toxic metals, conventional and nonconventional pollutants.
- Option B - Option B is equal to Option A preceded by flow reduction of process wastewater through the use of cooling towers for contact cooling water and holding tanks for all other process wastewater subject to recycle.
- Option C - Option C is equal to Option B plus end-of-pipe polishing filtration for further reduction of toxic metals and TSS.

- Option E - Option E consists of Option C plus activated carbon adsorption applied to the total plant discharge as a polishing step to reduce toxic organic concentrations.
- Option G - Option G consists of chemical oxidation applied to the total plant discharge, as a step to reduce toxic organic concentrations, without any other end-of-pipe treatment or pretreatment.

For each subcategory, limitations were based on one of the above treatment options. For three subcategories (Primary and Secondary Germanium/Gallium, Primary and Secondary Titanium, and Primary Zirconium/Hafnium), however, two types of plants have been identified. Therefore, two levels of limitations were developed and are being proposed for each of these subcategories.

For plants in the Primary and Secondary Germanium/Gallium subcategory, Level A limitations are based on lime and settle technology for plants that only reduce germanium oxide in a hydrogen furnace and then wash and rinse the germanium product in conjunction with zone refining. Level B limitations are proposed for facilities which perform any other operations, or any additional operations besides those described above.

Level A limitations for plants in the Primary and Secondary Titanium subcategory which do not practice electrolytic recovery of magnesium and which use vacuum distillation instead of leaching to purify titanium sponge as the final product are based on lime and settle technology. Level B limitations for all other titanium plants are based on lime and settle, flow reduction, and filtration technology.

For the Primary Zirconium/Hafnium subcategory, Level A limitations for plants which only produce zirconium or zirconium-nickel alloys by magnesium reduction of ZrO_2 are based on lime and settle and flow reduction. Level B limitations apply to plants which produce zirconium or hafnium from zircon sand or from the tetrachloride using any other or any additional operations to those described above. The proposed Level B limitations are based on lime and settle, flow reduction, and filtration.

Pollution control technologies result in two types of compliance costs: (1) capital costs for the control equipment, and (2) annual costs for operation and maintenance. Compliance costs are based on engineering estimates of the treatment alternatives described above and were developed for each plant after accounting for wastewater treatment already in place. These costs are used in this report to determine economic impacts.

The additional costs result in annual cash outflows to cover increased operating costs, increased maintenance expenditures, and the initial capital outlay to purchase control equipment. Tax benefits accrue from the Investment Tax Credit and from the deductibility of additional operating and depreciation expenses. These effects are combined in the computation of annual compliance costs, as described in Appendix C of the methodology.

Estimated compliance costs for this regulation are based on 1982 production levels (flow rates) as explained in the Development Document. For those subcategories where operating conditions in the impact period are expected to be an improvement over those experienced in 1982, compliance costs have been increased to account for higher flow rates. The factor by which costs are adjusted is the ratio of expected production at the time of compliance (based on average capacity utilization from 1978 to 1982) to actual (1982) production levels.

Table II-1 presents the annual compliance costs and investment costs for those subcategories containing plants incurring costs. The costs are summarized by discharge mode and totalled for each of these subcategories.

For existing discharging germanium/gallium, titanium, and zirconium/hafnium plants, only one cost level (Level A or B) is shown in Table II-1. The cost level is dependent on the type of production process used. For plants currently at Level A, the corresponding Level B costs are available in the confidential rulemaking record.

TABLE II-1

NONFERROUS SMELTING AND REFINING INDUSTRY --- COMPLIANCE COST ESTIMATES

(1982 dollars)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary Antimony									
Direct	1	36,634	13,698	36,634	13,698	44,137	16,767		
Indirect	0	0	0	0	0	0	0		
Total	1	36,634	13,698	36,634	13,698	44,137	16,767		
Bauxite Refining^a									
Direct	4							8,290,029	2,103,082
Indirect	0							0	0
Total	4							8,290,029	2,103,082
Primary Beryllium									
Direct	1			W	W	W	W		
Indirect	0			0	0	0	0		
Total	1			W	W	W	W		
Primary and Secondary Germanium/Gallium									
Direct	0	0	0	0	0	0	0		
Indirect	1	W	W	W	W	W	W		
Total	1	W	W	W	W	W	W		
Secondary Indium									
Direct	0	0	0	0	0	0	0		
Indirect	1	W	W	W	W	W	W		
Total	1	W	W	W	W	W	W		
Primary Molybdenum/Rhenium									
Direct	4	208,551	338,499	208,551	338,449	347,313	414,072		
Indirect	0	0	0	0	0	0	0		
Total	4	208,551	338,499	208,551	338,449	347,313	414,072		
Secondary Molybdenum/Vanadium									
Direct	1	W	W	W	W	W	W		
Indirect	0	0	0	0	0	0	0		
Total	1	W	W	W	W	W	W		

(Continued)

TABLE II-1 (Continued)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary Nickel/Cobalt									
Direct	1	W	W	W	W	W	W	W	W
Indirect	0	0	0	0	0	0	0	0	0
Total	1	W	W	W	W	W	W	W	W
Secondary Nickel									
Direct	0	0	0	0	0	0	0	0	0
Indirect	1	W	W	W	W	W	W	W	W
Total	1	W	W	W	W	W	W	W	W
Primary Precious Metals/									
Mercury									
Direct	1	27,500	8,610	27,500	8,610	29,975	9,755	29,975	9,755
Indirect	0	0	0	0	0	0	0	0	0
Total	1	27,500	8,610	27,500	8,610	29,975	9,755	29,975	9,755
Secondary Precious Metals									
Direct	3	299,535	240,155	299,535	242,505	306,846	251,434	306,846	251,434
Indirect	29	1,731,246	856,333	1,736,619	866,895	1,844,518	916,476	1,844,518	916,476
Total	32	2,030,781	1,096,488	2,036,154	1,109,400	2,151,364	1,167,910	2,151,364	1,167,910
Primary Rare-Earth Metals									
Direct	1	W	W	W	W	W	W	W	W
Indirect	1	W	W	W	W	W	W	W	W
Total	2	W	W	W	W	W	W	W	W
Secondary Tantalum									
Direct	3	7,270	44,708	7,270	44,708	15,437	48,962	15,437	48,962
Indirect	0	0	0	0	0	0	0	0	0
Total	3	7,270	44,708	7,270	44,708	15,437	48,962	15,437	48,962
Primary and Secondary Tin									
Direct	3	829,757	348,124	829,757	348,124	938,773	381,108	938,773	381,108
Indirect	2	W	W	W	W	W	W	W	W
Total	5	W	W	W	W	W	W	W	W

(Continued)

TABLE II-1 (Continued)

Subcategory	Number of Plants Incurring Costs	Option A		Option B		Option C		Option E	
		Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost	Investment Cost	Annual Cost
Primary and Secondary Titanium									
Direct	4	1,224,289	519,237	1,225,075	519,898	1,334,834	558,753		
Indirect	2	W	W	W	W	W	W		
Total	6	W	W	W	W	W	W		
Secondary Tungsten/Cobalt									
Direct	4	93,912	272,620	103,165	283,711	135,148	295,353		
Indirect	0	0	0	0	0	0	0		
Total	4	93,912	272,620	103,165	283,711	135,148	295,353		
Secondary Uranium									
Direct	1	28,600	49,301	28,600	49,301	54,313	58,379		
Indirect	0	0	0	0	0	0	0		
Total	1	28,600	49,301	28,600	49,301	54,313	58,379		
Primary Zirconium/Hafnium									
Direct	1	W	W	W	W	W	W		
Indirect	1	W	W	W	W	W	W		
Total	2	W	W	W	W	W	W		
Total Direct	33	3,670,516	2,958,317	3,689,630	2,974,588	4,241,416	3,207,845	W	W
Total Indirect	38	2,567,861	1,142,945	2,618,689	1,158,836	2,860,324	1,263,233	W	W
Industry Total^b	71	6,238,377	4,101,262	6,308,319	4,133,424	7,101,740	4,471,078	W	W

^aThe Agency is presently proposing only technical amendments to existing Bauxite regulations; however, it is considering toxic limitations on the net precipitation discharges from Bauxite red mud impoundments. The Bauxite numbers in this table and elsewhere in this document refer to the toxic limitations under consideration by the Agency.

^bThis figure represents the total compliance cost that would be incurred by the industry at each option. Some treatment levels are not viable options in certain subcategories. Total compliance costs for Option E include compliance costs for Option C plus incremental costs for Option E.

W -- Withheld to avoid disclosing company proprietary data.

CHAPTER III

OVERVIEW

III. OVERVIEW

There are 24 nonferrous metals manufacturing subcategories covered by this regulation. The Agency is proposing to completely exclude three of these subcategories (Primary Lithium, Primary Magnesium, and Secondary Zinc) from regulation. Primary Lithium and Secondary Zinc are excluded because these subcategories contain plants using only dry processes. Primary Magnesium plants are exempt because no treatable concentrations of pollutants were detected in their wastestreams. Each of the remaining 21 subcategories are discussed in the following chapters. The discussion begins with the structure of the industry, which includes descriptions of raw materials and production processes; plants in the subcategory; production, consumption, and trade characteristics; and end uses and substitutes. Market trends and developments are discussed next. Finally, a brief assessment of economic impacts on discharging plants is presented. Note that not all of the remaining metal subcategories contain discharging plants. Chapters on subcategories that contain no dischargers -- i.e., Primary Cesium/Rubidium; Secondary Mercury; and Primary Boron -- discuss only raw materials, production processes, and plants.

In order to facilitate the presentation of information concerning industry structure and processing technologies, certain subcategories have been combined on the basis of processing characteristics. For example, molybdenum and rhenium are combined in one chapter because rhenium is processed only as a byproduct of molybdenum production. These combinations are distinct from and do not necessarily correspond to those groupings developed for purposes of economic analysis.

CHAPTER IV

PRIMARY ANTIMONY SUBCATEGORY

IV. PRIMARY ANTIMONY SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Antimony is found in several minerals, but its most common ore is stibnite (antimony sulfide). Preparation for smelting varies with the grade of ore. Low-grade ores containing 5%-25% antimony are concentrated by roasting, which removes sulfur and other impurities, to yield volatile trioxide or nonvolatile tetroxide. Ores containing 45%-65% antimony are liquated to separate antimony from the other constituents. The ore is heated in a crucible or reverberatory furnace until the fused antimony collects at the bottom of the ore mass. Antimony trioxides, tetroxides, and fused antimony are then treated in a reverberatory furnace with coke and other charge materials such as soda ash and briquetted flue dust, to yield antimony metal. Water-jacketed blast furnaces are used in several modern plants to reduce intermediate grades, residues, mattes, and slags. High-grade ores, containing more than 65% antimony, are directly reduced to metal by iron precipitation. Fine iron scrap, when added to molten antimony sulfide, forms metallic antimony and iron sulfide.

Antimony metal is also prepared at several lead refineries. Used or discarded battery plates, type metal, and bearing metal scrap are first treated in a blast furnace and then further refined in a reverberatory furnace to yield antimonial lead, which generally contains 3%-12% antimony.

2. Description of Plants

Antimony metal and oxide producers in the United States are large, integrated companies with a wide scope of activity in marketing and manufacturing base metals and chemicals. Antimony oxide has been produced from both domestic and imported ores, from antimony metal, and from South African crude antimony oxide. Sunshine Mining Co. at Kellogg, Idaho and U.S. Antimony Corporation at Thompson Falls, Montana are the two major domestic mine producers of antimony. Sunshine Mining Co. produces antimony as a byproduct of the treatment of tetrahedrite, a complex silver-copper-antimony sulfide. The U.S. Antimony Corporation produces antimony from the stibnite mined at the Babitt, Bardot, and Black Jack mines at Thompson Falls, Montana. Asarco, Inc. has recently completed construction of a new antimony smelter at El Paso, Texas. Asarco's Denver, Colorado plant produces high purity antimony used in the electronics industry. The other major primary antimony producers are Anzon America, Inc., Laredo, Texas; AMSPEC Chemical Corp., Gloucester City, New Jersey; M&T Chemical Co., Baltimore, Maryland; and Chemet Co., Moscow, Tennessee.

The one plant under analysis is a direct discharger of effluents.

3. U.S. Production, Consumption, and Trade

The United States mines less than 10% of its domestic requirement for primary antimony. Imports, largely in the form of ores and concentrates, have come mainly from the Republic of South Africa, Bolivia, and mainland China. Domestic metal imports have fallen sharply from 1978 levels since the introduction of maintenance-free batteries. Exports have been small and mainly in the form of alloys. Table IV-1 shows that exports have been insignificant between 1978-1982. Old scrap, predominantly battery plates, has been the source of most of the secondary output. Essentially, all the reduced demand for antimony has been absorbed by the secondary sector; primary demand remained relatively constant. Most primary antimony produced from domestic sources is a byproduct or coproduct of silver, copper, or lead mining, smelting, and refining.

4. End Uses and Substitutes

Antimony metal and its various compounds have a wide variety of industrial uses. The metal has been used principally as an alloying constituent of lead and other metals, primarily for use in storage batteries. Antimonial lead is also widely used in the manufacture of chemical pumps and pipes, tank linings, roofing sheets, and cable sheath. Non-metallic antimony is used principally as a flame-retardant in textiles and plastics, as a decolorizing and refining agent in ceramics and glass, and as a vulcanizing agent in the rubber industry. Various chemical compounds of antimony are used in camouflage paints. The table below lists the major end-use markets for antimonial products in 1982.

End-Use Market	% 1982 U.S. Antimony Consumption
Flame retardants	60
Transportation, including batteries	15
Ceramics and glass	10
Chemicals	5
TOTAL	100

Substitutes exist for antimony in all its major uses. Selected organic compounds which are less toxic and cheaper are used as substitutes in flame-retardant systems. However, antimony is still used as a flame-retardant in the plastic insulation of electric cables

TABLE IV-1

U.S. ANTIMONY PRODUCTION, CONSUMPTION, AND TRADE

(short tons of antimony content)

	1978	1979	1980	1981	1982
Production					
Mine	798	722	343	646	503
Primary plants ^a	14,110	15,062	16,062	17,761	12,282
Secondary plants	26,456	24,155	19,893	19,856	16,596
Consumption ^b	40,536	42,846	33,817	35,296	31,199
Trade -- Metal Imports	4,178	3,022	2,590	2,631	1,900
Trade -- Metal and Alloy Exports	556	485	453	324	830

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

^aIncludes antimony recovered as antimonial lead from smelting lead ore.

^bDerived from both primary and secondary sources.

because alternative materials affect plastic's mechanical qualities. Calcium combined with a little tin is rapidly replacing antimony in car batteries since the introduction of maintenance-free batteries, in spite of the fact that calcium-lead batteries are more difficult to charge.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

There is an active free market in antimony metal, ore, and trioxide, but the prices of these three items have little relationship to each other in the short run. The antimony metal market is rather volatile and attracts speculation, mainly from the merchants who deal in it. The unpredictable marketing policy of China, the main metal producer, further reinforces this feature. Changing patterns of distribution have also resulted in fluctuations in antimony price. Since 1978, prices for antimonial lead or "antimony in alloy" have been quoted by major domestic secondary lead smelters.

The plant under analysis is a major metal producer. The estimated revenues of this plant have been calculated using the average price of the 1978-1982 period, \$1.519 per pound. Although domestic demand has declined in recent years, demand by foreign automobile manufacturers has kept plants operating at normal levels. With overall demand remaining relatively constant, prices are not expected to deviate from average levels. Table IV-2 lists published antimony metal prices between 1978 and 1982.

2. Capacity Utilization

U.S. demand for antimony has remained relatively constant over the past decade. Antimony has a specialized consumption pattern that does not conform to general economic patterns, but to specific end-use markets such as storage batteries, textiles, plastics, and rubber. Over the past four or five years demand patterns have changed noticeably. Consumption of antimony by the automobile industry has declined substantially due to lower use in the manufacture of automotive batteries. Demand for antimony oxide, on the other hand, has risen significantly, for use in flame-retardant formulations. Most of the antimony chemicals also fall into established use patterns. The U.S. Bureau of Mines forecasts that with increased demand for colored enamel, glass, color television, and other appliances, antimony will continue to be used by the ceramics and glass industries. Industry capacity utilization rates are listed in Table IV-3. The average capacity utilization rate over the 1978-1982 period, 45%, is used in the analysis.

TABLE IV-2

U.S. ANTIMONY METAL PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	1.145	1.578
1979	1.407	1.783
1980	1.508	1.749
1981	1.355	1.436
1982	1.050	<u>1.050</u>
Average price = \$1.519		

SOURCE: Mineral Commodity Summaries,
U.S. Department of the Interior,
Bureau of Mines, 1983.

TABLE IV-3
ANTIMONY METAL -- CAPACITY UTILIZATION

Year	Production (short tons)	Capacity (short tons)	Capacity Utilization (%)
1978	1,108	2,200	50
1979	2,642	2,800	94
1980	507	2,300	22
1981	790	2,300	34
1982	539	2,300	<u>23</u>
Average capacity utilization = 45%			

SOURCE: Capacity data -- Personal communication,
U.S. Department of the Interior, Bureau of
Mines, February 1984.

Production data -- Minerals Yearbook, U.S.
Department of the Interior, Bureau of
Mines, 1982.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the Primary Antimony subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for the one plant identified as a discharger of effluents. However, closure analysis indicates that this plant will not close. In addition, compliance costs for this subcategory are less than 3.4% under the most stringent option.

CHAPTER V

BAUXITE REFINING SUBCATEGORY

V. BAUXITE REFINING SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

The term "bauxite" refers to aluminous mixtures rich in alumina and low in alkalis, alkaline earths, and silica. The bauxite refining process removes impurities in the ore, and converts bauxite to aluminum oxide, or alumina (Al_2O_3). The principal ore from which alumina and aluminum are made is composed of aluminum hydroxide minerals and impurities, such as silicon dioxide, ferrous oxide, and titanium dioxide. There are three major types of bauxite: (1) gibbsite ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), (2) monohydrate ($\text{AlO}(\text{OH})$), and (3) a mixture of gibbsite and monohydrate. Economically minable bauxites contain 30%-60% alumina, 3%-25% iron oxide, 1%-15% combined silicon dioxide (silica), 1.5%-3.5% titanium dioxide, and a large amount of water.

The Bayer process is the only commercial-scale method of converting metallurgical-grade bauxite to alumina. In the classic Bayer process, aluminum and other soluble elements in bauxite are dissolved at elevated temperatures and pressures in a strong alkali solution, generally NaOH , to form sodium aluminate (NaAlO_2). After separation of the "red mud" tails, the sodium aluminate solution is cooled and seeded, and aluminum trihydrate is precipitated in a controlled form. The trihydrate is dewatered and calcined to the anhydrous crystalline form, alumina.

Alumina plants are designed to process specific grades of bauxite. Depending on the mineral content of the ore, variations occur in the digestion temperature, pressure, and caustic concentration. In addition, higher silica ores (greater than 8% SiO_2) require additional steps, known as the lime-soda-sinter process, to recover alumina and soda lost by combination with silica; this procedure is known as the Combination process. There are two other variations of the Bayer process: the American Bayer process, which refines trihydrate ore, and the European Bayer process, which refines monohydrate ore. Trihydrate ores containing up to 25% monohydrate recently have been processed by a method known as the Modified Bayer process. The vast majority of the alumina produced, and for several of the plants the total output, goes directly to aluminum smelters for primary metal production. Alumina is also used for nonmetallurgical purposes in ceramics and refractories production.

2. Description of Plants

Domestic alumina plants produce calcined alumina, commercial alumina trihydrate and other specialty alumina forms. The Alcoa facility at Point Comfort, Texas, and the Kaiser facility at Gramercy, Louisiana also produce alumina trihydrate. Two Arkansas plants (Alcoa and Reynolds) use bauxite mined in the general vicinity of the plants; all other refineries use imported bauxite. Kaiser, at Baton Rouge, and Reynolds, at Corpus Christi, use bauxite from mines which they own and operate in Jamaica. Bauxite from Guinea is now used exclusively at both Martin Marietta's St. Croix and Alcoa's Point Comfort plants. In previous years, Alcoa relied heavily on ore from its mines in Surinam for its U.S. refineries. Bauxite for Ormet's Burnside, Louisiana refinery is from several sources.

Four of the eight alumina producers do not produce any wastewater; consequently, they will not be analyzed any further. All the remaining plants are direct dischargers of effluents. One of these plants was shut down in 1983; however, normal operations may resume at some later date. In addition, large amounts of wastewater still remain in holding ponds.

3. U.S. Production, Consumption, and Trade

Domestic production of bauxite has declined continuously since 1979. Table V-1 shows that 1982 production was estimated to be approximately 62% below 1979 levels. The decline has been largely due to the high cost of mining operations. Domestic alumina production also registered a fall of about 35% from the 1980 level of 8,094,000 metric tons. Thus, the U.S. has relied heavily on imports of refractory-grade and abrasive-grade aluminous materials. Alumina imports, primarily from Australia (76%), Jamaica (15%), and Surinam (8%), ranged between 3.0-4.5 million metric tons between 1978 and 1982. Domestic consumption and exports also registered declines in 1982; the 3.7 million metric tons consumed was approximately 34% below the 1981 level, and exports, though limited, fell approximately 43% below the 1978 level, to 500,000 metric tons.

4. End Uses and Substitutes

The U.S. alumina industry produces nonmetallurgical alumina and aluminum hydroxide for various industrial applications. Approximately 90% of the alumina produced is used to make primary aluminum. Most of the remainder is used by the abrasive, refractory, and chemical industries. As a refractory material, it is used to line the furnaces and ladles of the steel, copper, aluminum, and glass-producing industries. Abrasive-grade calcined alumina is used for precision

TABLE V-1

U.S. BAUXITE AND ALUMINA PRODUCTION, CONSUMPTION, AND TRADE

(thousands of dry metric tons)

	1978	1979	1980	1981	1982 ^a
Production					
Bauxite	1,669	1,821	1,559	1,510	700
Alumina	7,220	7,345	8,094	7,120	5,265
Consumption					
Bauxite and alumina	5,300	5,106	5,824	5,555	3,700
Imports					
Bauxite	14,500	14,800	14,700	13,300	12,500
Alumina	3,967	3,837	4,358	3,978	3,200
Exports					
Bauxite ^b	13	15	33	52	50
Alumina	878	849	1,138	737	500

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

^aEstimated.

^bIncludes all forms of bauxite.

grinding, surfacing, and polishing metal goods. Alumina hydrates are widely used as fire-retardants in carpet-backing, plastics, and furniture upholstery. Activated alumina, which is highly porous and absorbent, is used to dehydrate liquids and gases in the chemical and petroleum industries. There are no satisfactory substitutes.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Most world trade transactions in alumina involve long-term contracts or intra-company transfers. Consequently, prices, other than for spot sales or special grades, are not quoted in trade journals as they are for commodities traded on the open market. As Table V-2 shows, domestic shipments of calcined alumina were valued at \$236 per ton in 1981 and at \$260 per ton in 1982. The average value of domestic shipments for the 1978-1982 period was estimated at \$242 per ton. Imported alumina was valued at \$222 per ton at U.S. ports in 1981. The corresponding figure for 1982 was \$268 per ton. In spite of the recession, alumina prices rose in 1982 as a result of escalating domestic mine development costs following the increase in energy costs. Some countries have also imposed production levies, which have pushed up alumina prices. The continuing high demand for the aluminum metal ensures a sustained growth rate in the demand for alumina. The 1978-1982 average price of \$242 per ton is used in the analysis.

2. Capacity Utilization

Most of the alumina consumed in the United States is used to make aluminum metal. The alumina plants have, therefore, adjusted their operating capacity according to conditions in the aluminum market. The high demand for aluminum metal has enabled domestic alumina plants to operate at 80%-90% of their capacity. Table V-3 indicates that the industry operated at an average capacity of 80% between 1978-1982. The United States is expected to continue to produce a major proportion of the primary aluminum metal it consumes, although an increasing proportion of the metal demand is expected to be met by imports from countries with low-cost electric energy.

The Bureau of Mines estimates that demand for primary aluminum metal in the United States will increase at an annual rate of 4.5% through 1990 from a 1978 base. The increasing imports of metal will result in a somewhat low annual rate of increase in demand for alumina. Nevertheless, the increasing demand should help alumina producers to at least maintain their historical average capacity utilization rates. The average capacity utilization rate between 1978-1982, 80%, is used in the analysis.

TABLE V-2

ALUMINA PRICES

Year	Average Annual Price, Dollars per Ton	
	Actual	1982 Dollars
1978	164	226
1979	173	219
1980	218	253
1981	236	250
1982	<u>260</u>	<u>260</u>
Average price = \$242		

SOURCE: Minerals Yearbook, U.S. Department of
the Interior, Bureau of Mines, 1982.

TABLE V-3

ALUMINA CAPACITY UTILIZATION

(thousands of metric tons of calcined alumina)

Year	Production	Capacity	Capacity Utilization (%)
1978	5,960	7,208	83
1979	6,450	7,208	89
1980	6,810	7,208	94
1981	5,960	7,420	80
1982	4,130	7,495	<u>55</u>
Average capacity utilization = 80%			

SOURCE: Minerals Yearbook, U.S. Department of
the Interior, Bureau of Mines, 1982.

C. IMPACT ASSESSMENT

The Agency is presently proposing only technical amendments to existing Bauxite regulations; however, it is considering toxic limitations on the net precipitation discharges from Bauxite redmud impoundments. The toxic limitations under consideration, if implemented, are not expected to have a significant impact on plants in the Bauxite Refining subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for any plant in the subcategory. No plant is projected to close. In addition, compliance costs are less than 0.4% of production costs under the most stringent treatment option. Comments are solicited on the limitations under consideration and their potential impacts.

CHAPTER VI

PRIMARY BERYLLIUM SUBCATEGORY

VI. PRIMARY BERYLLIUM SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

The U.S. is currently the only market economy nation producing beryllium products from beryllium minerals. There are two principal beryllium minerals: bertrandite and beryl. Bertrandite is the principal beryllium mineral produced domestically; beryl is the principal beryllium mineral produced in the rest of the world. U.S. beryllium production is derived from both domestic bertrandite ore and imported beryl ore. In both cases, the ore is first converted to beryllium hydroxide and then to beryllium oxide. The oxide is further processed into beryllium metal or directly into beryllium-copper alloy. Due to the difficulty of fabricating beryllium metal parts, cast ingots are machined into chips and then ground into powder, which is then compacted by hot-pressing under vacuum. A significant amount of metallic beryllium is also produced from used and discarded materials.

Beryllium-copper alloy is the most commonly produced beryllium alloy. Other alloys are beryllium-aluminum and beryllium-nickel. Beryllium-copper alloys usually contain about 2%-4% beryllium. The production of beryllium alloys is covered under copper-forming regulations.

2. Description of Plants

Brush Wellman, Inc. (BWI) and the Cabot Berylco Division of the Cabot Corp. have been identified as domestic beryllium producers. BWI mines bertrandite ore in Utah and converts it to an impure beryllium hydroxide. The hydroxide is then sent to the BWI plant in Elmore, Ohio, or to the Cabot Berylco plant in Reading, Pennsylvania for conversion into beryllium products. The BWI plant converts beryllium hydroxide into beryllium oxide, which is then used to produce both beryllium metal and alloy products. The plant also manufactures high purity beryllium oxide for various applications in ceramics. One plant in this subcategory has been identified as a direct discharger of effluents.

3. U.S. Production, Consumption, and Trade

The U.S. is both a major world producer and consumer of beryllium minerals. The Agency's data indicate that domestic industry relies primarily on domestically mined bertrandite ore, but has, in recent years, become increasingly dependent on imported beryl ore.

Table VI-1 shows that between 1978 and 1982, beryllium produced from imported beryl ore increased from 15% to 33% of domestic consumption. Further development of the bertrandite deposit in Utah mined by Brush Wellman, Inc. could make the U.S. self-sufficient in beryllium by the year 2000. However, BWI has initiated a program to stimulate domestic and foreign beryl mining in order to extend the life of the Utah deposit and to make full use of the company's beryl ore processing capacity. As a consequence of this effort, beryl imports are expected to become an increasingly important raw material for beryllium production. The government currently stockpiles beryl concentrate, beryllium-copper master alloys, and beryllium metal.

4. End Uses and Substitutes

Copper-based beryllium alloys are the most widely used beryllium-containing products. As shown in the table below, various uses in the aerospace, electrical equipment, and electrical component markets account for most domestic consumption. Beryllium-copper alloys and beryllium oxide ceramics have been used increasingly in the electronic and electrical equipment industries. Beryllium metal, with its high stiffness-to-weight ratio and excellent thermal conduction properties, has found numerous applications in aerospace fields.

End-Use Market	% 1982 U.S. Beryllium Consumption
Aerospace	38
Electrical equipment	36
Electrical components	17
Other	9
TOTAL	100

Steel, titanium, and graphite composites may be substituted for beryllium metal. Phosphor bronze may be substituted for beryllium-copper alloys. However, these substitutions generally result in a substantial loss of performance.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Because of the health and environmental dangers involved in producing this toxic metal, and the small markets which exist for it, beryllium is manufactured by only a few producers. Consequently, these producers can effectively control market prices. Prices in 1982 dollars are shown in Table VI-2 for the years 1978-1982. Bureau of Mines estimates of steady demand growth, coupled with rigid price controls by producers, suggest that prices will not fall below these levels.

TABLE VI-1

U.S. BERYLLIUM CONSUMPTION AND TRADE
(short tons of contained beryllium)

	1978	1979	1980	1981	1982 ^a
Consumption	271	303	321	303	328
Trade -- Imports (beryl ore)	42	43	74	87	108
Trade -- Exports (metal and alloy)	41	36	--b	--b	--b

SOURCE: Mineral Commodity Summaries, U.S. Department of the
Interior, Bureau of Mines, 1983.

^aEstimated.

^bData not available.

TABLE VI-2

BERYLLIUM INGOT PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	120	165
1979	120	152
1980	140	162
1981	173	183
1982	205	<u>205</u>
Average price = \$173		

SOURCE: Mineral Facts and Problems, 1980 and
Mineral Commodity Summaries,
U.S. Department of the Interior,
Bureau of Mines, 1983.

2. Capacity Utilization

The Agency's data indicate that during 1982 the only discharging plant operated at almost full capacity. Indications are that demand growth will support this level of operations into the near future. Therefore, the value of products produced in 1982 will be used in the following analysis as a proxy for sales.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the primary beryllium subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for the one plant identified as a discharger of effluents. This plant is not projected to close. In addition, compliance costs for this subcategory are less than 0.1% of production costs under the most stringent treatment option.

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CHAPTER VII

PRIMARY AND SECONDARY GERMANIUM/GALLIUM SUBCATEGORY

VII. PRIMARY AND SECONDARY GERMANIUM/GALLIUM SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

a. Germanium

The principal source of raw material for domestic primary germanium production is residue from zinc processing. U.S. germanium production is, therefore, dependent on the rate of zinc processing. Domestic producers also produce germanium by recycling scrap obtained from manufacturing processes. Germanium oxides are recovered from zinc residues and then chlorinated to produce germanium tetrachloride. The tetrachloride is hydrolyzed to obtain germanium dioxide, which is reduced with hydrogen to yield germanium powder. Germanium is available in a wide variety of forms.

b. Gallium

Gallium is found in most bauxite and zinc ores. However, because gallium usually occurs in very low concentrations, recovery is expensive and not often undertaken. Gallium is recovered from caustic soda solution used in the conversion of bauxite to alumina or recovered from zinc processing residues. Small quantities are also produced from scrap.

2. Description of Plants

a. Germanium

In 1982, the domestic germanium industry consisted of three producers. The Specialty Materials Division of Eagle-Picher Industries recovered germanium from stockpiled zinc smelter residues in Quapaw, Oklahoma. Two other companies also produced germanium: they are the Cabot Corporation in Revere, Pennsylvania and Bunker Rare Metals, Inc. in Irving, Texas. Bunker Rare Metals produces germanium from germanium dioxide. One of these plants has been identified as an indirect discharger of effluents and will be further analyzed.

b. Gallium

One domestic company produced primary gallium in 1982. Eagle-Picher Industries in Quapaw, Oklahoma produced gallium, along with germanium, from stockpiled zinc smelter residue. Secondary production was performed by Canyonlands 21st Century in Blanding, Utah and Gallus in San Jose, California. Because no gallium facility was identified as a discharger of effluent waste, further analysis of this subcategory is not required.

Two types of plants, Level A and Level B, have been identified in this subcategory (see Chapter II). The one discharging germanium plant and the zero discharging gallium plants have been identified as Level A plants. The Agency has considered the possibility that these Level A plants may at some point engage in Level B processes and therefore be subject to Level B limitations. The impacts of these limitations have been estimated and are discussed in Chapter XXV--Limitations of the Analysis.

3. U.S. Production, Consumption, and Trade

While only estimates are available, it appears that U.S. germanium production increased at an average annual rate of 8% between 1978 and 1982. During this same period, however, consumption increased at an average annual rate of about 16%. Table VII-1 shows that in order to meet this growing demand, imports doubled as a percentage of domestic consumption, rising from 12% in 1978 to 24% in 1982. The abnormally large tonnage imported in 1981 was primarily in the form of low-grade waste and scrap. Germanium is not stockpiled by the U.S. government.

4. End Uses and Substitutes

For many years, germanium was used chiefly in the manufacture of various semiconductor devices. Recently, silicon has largely replaced many of these traditional applications. However, new and developing applications in infrared optic systems, such as nightsighting systems for tanks and aircraft, and in fiber optics, where germanium increases the efficiency of long-distance transmissions, have more than compensated for this lost demand. The table below shows the breakdown of germanium consumption by major end uses in 1982.

TABLE VII-1

U.S. GERMANIUM PRODUCTION, CONSUMPTION, AND TRADE

(kilograms of contained germanium)

	1978	1979	1980	1981	1982
Production ^a	19,200	23,000	27,000	28,000	26,000
Consumption ^a	22,900	24,000	32,000	38,000	42,000
Trade -- Imports ^b	2,657	4,029	3,329	22,350	10,000

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

^aEstimated.

^bGross weight of wrought metal, waste, and scrap.

End-Use Market	% 1982 U.S. Germanium Consumption
Infrared optics	43
Semiconductors	18
Fiber optic systems	16
Radiation detectors	12
Other	11
TOTAL	100

While silicon has been substituted for germanium in certain electronic applications, germanium is still more reliable in some high-frequency and high-power applications, and is more economical as a substrate for some light-emitting diode applications. In infrared guidance systems zinc selenide can substitute for germanium metal but results in a lower level of performance.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Producer list prices for zone-refined ingot are shown in Table VII-2. Zone-refined ingot is a commonly produced high-purity form of germanium metal. Prices rose dramatically during 1980 and 1981 when zinc residue shortages constrained supply. However, during 1982 demand slowed as a result of both the spreading out of military purchases and the improvement in fiber optic production techniques and products. The strength of the dollar induced lower-priced imports, especially from Belgium, which increased competition and caused further downward price pressure. Nevertheless, the list price has been maintained at \$1,060 per kilogram, and buying at discount is now standard. The average producer price between 1978-1982, \$847 per kilogram, will be used in the analysis.

2. Capacity Utilization

The capacity utilization of domestic germanium-producing facilities is computed from industry operational capacity and estimated industry production data. These figures are summarized for the 1978-1982 period in Table VII-3. Capacity utilization rates, which had been held down by zinc residue shortages in 1980 and 1981, were kept low during 1982 as the demand for germanium slowed. The average capacity utilization between 1978-1982, 60%, will be used in the analysis.

TABLE VII-2

ZONE-REFINED GERMANIUM PRICES

Year	Average Annual Price, Dollars per Kilogram	
	Actual	1982 Dollars
1978	348	479
1979	522	662
1980	784	909
1981	1,060	1,124
1982	1,060	<u>1,060</u>
Average price = \$847		

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

TABLE VII-3

GERMANIUM CAPACITY UTILIZATION

Year	Estimated Production (kilograms)	Capacity (kilograms)	Capacity Utilization (%)
1978	19,200	40,000	48
1979	23,000	40,000	58
1980	27,000	40,000	68
1981	28,000	40,000	70
1982	26,000	44,500	58
Average capacity utilization = 60%			

SOURCE: Production data -- Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1982.

Capacity data -- Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on the germanium facilities in this subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for the one plant identified as a discharger of effluents. However, closure analysis indicates that this plant will not close. In addition, compliance costs for this subcategory are less than 1.25% of production costs under the most stringent treatment option.

CHAPTER VIII

SECONDARY INDIUM SUBCATEGORY

VIII. SECONDARY INDIUM SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Indium is usually recovered as a byproduct of zinc processing. However, most zinc is so poor in indium that recovery is not attempted. At those facilities that do recover indium, the value of indium recovered is negligible in relation to the value of zinc production.

In the zinc refining process, indium is removed along with lead from crude zinc by fractional distillation. Crude indium is then recovered from the lead through an involved procedure of pyrometallurgy, leaching, purification, and cementation. Secondary indium is produced by dissolving indium scrap in acid and chemically precipitating the crude indium. Because almost all uses require a high purity form of indium, crude indium, either primary or secondary, is then refined by electrolytic methods.

2. Description of Plants

One company in the United States produced indium during 1982. The Indium Corporation of America in Utica, New York refined indium from crude indium metal. This crude metal is purchased from domestic and foreign sources on the open market. The Agency has identified this plant as an indirect discharger of effluents.

3. U.S. Production, Consumption, and Trade

Very little production, consumption, and trade information is available on indium. Agency data indicate, however, that imports supply approximately three-fourths of domestic demand. Indium refiners have had to rely increasingly on imports of crude indium due to the paucity of suitable domestic residues. As shown in Table VIII-1, imports, primarily in the form of crude metal, increased at an average annual rate of 35% between 1978-1982. It is estimated that the U.S. consumes 30% of world production. Indium is not stockpiled by the government.

4. End Uses and Substitutes

The table below presents a breakdown of indium consumption by end-use market. Indium end uses continue to evolve as new applications and substitutes develop. Domestic usage is now dominated by various solder, alloy, and coating applications. Indium's low melting point and

TABLE VIII-1

U.S. INDIUM CONSUMPTION AND IMPORTS

(thousands of troy ounces)

	1978	1979	1980	1981	1982 ^a
Consumption	630	650	--- ^b	-- ^b	-- ^b
Imports	206	294	299	446	685

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

^aEstimated.

^bData not available.

corrosion resistance are crucial to many of these applications. Indium is also required by the electronics industry; however, use by this industry has declined in recent years due to substitution.

End-Use Market	% 1982 U.S. Indium Consumption
Electrical and electronic components	40
Solders, alloys, and coatings	40
Research and other	<u>20</u>
TOTAL	100

Alternate materials are readily available for most uses of indium. In the electronics industry, silicon has generally replaced germanium-indium components. In some alloys, if cost permits, gallium is used as a substitute. Boron carbide and hafnium have largely replaced indium in nuclear reactor control rods.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Table VIII-2 shows that indium prices fluctuated widely between 1978 and 1982; however, supply and demand remained roughly in balance throughout this period. The 67% price increase from 1978 to 1980 is believed to have been fueled by expectations of increasing applications for indium, and related expectations of increasing demand. When expected demand did not materialize, prices fell 80% in just two years. Increased imports, slight over-production, and flat demand led to a 1982 year-end price of \$2.60 per troy ounce and an average annual price of \$4.20 per troy ounce. Uncertain demand arising from the variability of end uses and substitutes and an adequate world capacity are expected to hold prices at this low level in the immediate future.

2. Capacity Utilization

The value of products produced in 1982 is available for the one discharging plant under consideration. Because current market conditions are expected to persist, this value of revenue will be used in the analysis as a proxy for sales.

TABLE VIII-2

INDIUM PRICES

Year	Average Annual Price, Dollars per Troy Ounce	
	Actual	1982 Dollars
1978	8.56	11.79
1979	13.48	17.09
1980	17.00	19.71
1981	7.53	7.98
1982	4.20	4.20
Average price = \$12.15		

SOURCE: Mineral Commodity Summaries,
U.S. Department of the Interior,
Bureau of Mines, 1983.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the Secondary Indium subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for the one plant identified as a discharger of effluents. However, closure analysis indicates that this plant will not close. In addition, compliance costs for this subcategory are less than 1.4% of production costs under the most stringent treatment option.

CHAPTER IX

PRIMARY MOLYBDENUM/RHENIUM AND
SECONDARY MOLYBDENUM/VANADIUM
SUBCATEGORIES

IX. PRIMARY MOLYBDENUM/RHENIUM AND
SECONDARY MOLYBDENUM/VANADIUM SUBCATEGORIES

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

a. Molybdenum

Molysulfide (MoS_2) is the principal raw material from which molybdenum and molybdenum products are obtained. Molysulfide is obtained from two sources. About 70% of the molysulfide used in the U.S. is produced from primary molybdenite ore. The remaining 30% is recovered as a byproduct of copper ore concentration operations. The Agency has identified 14 U.S. firms which produced molysulfide during 1982. Climax Molybdenum Co. and MolyCorp, Inc., which mine primary molybdenite ore, and Duval Corp. and Kennecott Corp., which recover molybdenum from copper ore, are the principal producers of molysulfide.

As a first step in the production of molybdenum, molysulfide is "roasted" to produce technical-grade molybdic oxide ("tech oxide") that has a minimum molybdenum content of 57%. Then, depending on the markets (customers) they serve, U.S. plants produce several products from technical-grade oxide. These include:

- pure molybdic oxide;
- ammonium and sodium molybdate;
- ferromolybdenum; and
- molybdenum metal.

Small quantities of molybdenum are also recovered as byproducts from tungsten and uranium operations.

b. Rhenium

Rhenium is produced commercially only as a byproduct of molybdenum production. Production is made possible by the large tonnage involved in the mining and processing of copper ores. At standard molybdenum roasting temperatures, rhenium oxides are carried off with roaster flue gas. These oxides are then recovered from the gases (using wet scrubbers and electrostatic precipitators) in the form of ammonium perrhenate. High purity rhenium metal powder (99.99%) can be produced from ammonium perrhenate through two-stage hydrogen reduction.

Despite the large scale of domestic molybdenum operations, only a small amount of rhenium is actually produced. This is because molybdenum producers often have either no extraction plant or have found extraction uneconomical. Therefore, the U.S. relies heavily on imports to satisfy demand. These imports are predominantly in the form of ammonium perrhenate, although some metal products are also imported.

c. Vanadium

Vanadium is usually produced as a byproduct or coproduct of another element, commonly uranium or phosphorus in the United States. Secondary vanadium is recovered from the residues of crude oil and tar sands, spent catalysts, and slags. Vanadium metal extracted from spent catalysts is converted into fused vanadium pentoxide or ammonium metavanadate. For chemical purposes, these two vanadium compounds are the ones most frequently demanded.

2. Description of Plants

a. Molybdenum

Molybdenum plants can be classified into four major categories. Plants in the first category process molybsulfide. Although they produce other products and metals, most of their output can be attributed to molybdenum production. The only exception in this class is the Magna, Utah plant of the Kennecott Corp. Here, molybdenum is produced as a byproduct of copper production and accounts for less than 2% of the value of plant shipments.

Seven plants converted molybdenite (MoS_2) concentrate to molybdic oxide (MoO_3) in 1982. These plants have the capacity to produce about 125 million pounds of molybdic oxide. The two plants owned by AMAX alone have a total capacity of almost 90 million pounds (or about 70% of the industry's capacity). The plant owned by MolyCorp currently has a capacity to produce 6 million pounds per year; however, the company was planning to expand the capacity to 20 million pounds before the 1981-1982 recession started. The S.W. Shattuck Co. plant in Denver and the M&R Refractory Metals Co. plant in New Jersey, in general, process moly concentrate on a toll basis -- that is, these companies process concentrate owned by other companies. The M&R plant is somewhat unique in that it also produces molybdenum in pure metal form by removing oxygen from MoO_3 . Furthermore, it produces tungsten and cobalt from the respective metallic oxides by employing processes that are identical to the process used to create molybdenum from tech oxide.

Five of the plants have been identified as zero-discharging facilities. Two plants have been identified as direct dischargers and will be analyzed further. These two plants have been determined to be identical to plants in the metallurgical acid plant subcategory of the recently promulgated regulations for Nonferrous Metals Manufacturing Phase I (49 FR 8742). Consequently, this rulemaking proposes to include the two plants in that subcategory. The limitations proposed for these plants (and the recommended technologies on which they are based) are identical to those promulgated for the Phase I metallurgical acid plant subcategory. As a result, there is no difference in the manner in which compliance costs were estimated for plants in the two subcategories.

Plants in the second category have the following general characteristics:

- they do not process molybdenesulfide;
- they produce molybdenum in pure metallic form and transform it into formed product; and
- they produce other metals and metallic products in large quantities.

Hence, molybdenum refining operations constitute a very small part of the total operations. As a result, the value of shipments that can be attributed to molybdenum production is likely to be less than 10% of the value of shipments from a plant. Correspondingly, the molybdenum employment is also very small.

At these plants, molybdenum is generally recovered as a byproduct of other operations. For example, at the GE plant in Cleveland, Ohio and the North American Philips Corp. plant in Lewiston, Maine, molybdenum is obtained as a byproduct of tungsten production. In fact, it must be removed from tungsten ore before the ore can be used for tungsten production. The molybdenum produced at these plants is normally used "captively" to produce products for electrical and other applications. Two plants in this category have been identified as direct dischargers and will be analyzed further.

Plants in the third category recover oxides from spent catalysts used by the oil and gas industry. Only a few years ago, two or three plants produced molybdenic oxide from recycled materials. However, Gulf Chemical and Metallurgical Company in Freeport, Texas is the only plant in operation today. This plant recovers molybdenic oxide and vanadium pentoxides from petroleum refining catalysts. The plant's major customers are catalyst manufacturers. This plant is a direct discharger and will be analyzed in the Secondary Molybdenum/Vanadium subcategory.

Plants in the fourth category produce molybdenum as a byproduct of uranium operations. The total amount of molybdenum produced in this way, however, is rather small. Because no plants have been identified as dischargers in this category, further analysis of plants in this category is not required.

b. Rhenium

During 1982, the bulk of domestic rhenium was processed by two plants. The Kennecott Corp. in Magna, Utah produced ammonium perrhenate from domestic porphyry copper ores. The S.W. Shattuck Chemical Co. plant in Denver, Colorado recovered rhenium, in various forms, from Canadian molybdenite concentrates.

The Agency has determined that these plants do not discharge effluents. Therefore, analysis of the impacts of Phase II regulation will not be performed for these plants.

c. Vanadium

The Agency has identified one plant in the Secondary Molybdenum/Vanadium subcategory. Gulf Chemical and Metallurgical Company in Freeport, Texas recovers vanadium pentoxides and molybdic oxides from spent catalysts supplied by oil refineries and petrochemical plants. The plant's major customers are catalyst manufacturers. This facility is a direct discharger.

3. U.S. Production, Consumption, and Trade

a. Molybdenum

The U.S. is the world's largest producer and exporter of molybdenum. Between 1978 and 1981, domestic consumption was approximately equal to exports. Of these exports, about 97% were in the form of concentrate or technical-grade oxide. Table IX-1 presents domestic molybdenum production, consumption, and trade figures. As can be seen, 1982 production fell to about half of 1980 production due to the worldwide economic recession. Because there are ample supplies of molybdenum, it is not stockpiled by the U.S. government.

b. Vanadium

Small quantities of spent catalyst-containing vanadium are purchased by dealers and sold to processors for recovery. Trade figures concerning this activity are not compiled.

TABLE IX-1

U.S. MOLYBDENUM PRODUCTION, CONSUMPTION, AND TRADE^a
(thousands of pounds molybdenum content)

	1978	1979	1980	1981	1982 ^b
Production	131,843	143,967	150,686	139,900	75,000
Consumption	67,724	73,682	60,754	61,103	33,000
Trade -- Exports (concentrate and oxide)	69,150	72,242	68,217	52,436	45,000
Trade -- Imports (concentrate)	2,705	2,329	1,825	1,988	3,400

SOURCE: Mineral Industry Surveys -- Molybdenum, U.S. Department of the Interior, Bureau of Mines, December, 1982.

^aUnprocessed molybdenum ore; large quantities of the concentrate (concentrated molysulfide) are exported without processing.

^bEstimated.

4. End Uses and Substitutes

a. Molybdenum

Steel alloys account for about 70% of molybdenum consumption. Technical-grade molybdic oxide and ferromolybdenum are the principal forms of molybdenum used to make steel. Metallurgical applications, which include the use of molybdenum in steels, cast irons, alloys, and as a refractory metal, are common to the machinery and tool, oil and gas, and transportation equipment industries. Among nonmetallurgical uses, the principal applications are in lubricants, catalysts, electrical products, and pigments. The table below shows the breakdown of molybdenum consumption by major end markets in 1982.

End Market	% 1982 U.S. Molybdenum Consumption
Machinery and tools	34
Oil and gas industry	20
Transportation equipment	17
Chemicals	13
Electrical	8
Other	8
TOTAL	100

Molybdenum's availability, low cost, and overall performance have provided little impetus for the use of substitutes. Potential substitutes do exist however, including: chromium, vanadium, columbium, and boron in alloy steels; tungsten in tool steels; graphite, tungsten, and tantalum for refractory materials in high temperature electric furnaces; and chrome-orange, cadmium-red, and organic-orange pigments for molybdenum orange.

b. Vanadium

While the main use of vanadium is as an alloying ingredient in steel, the metal plays an important role as a catalyst in certain chemical reactions. Vanadium catalysts are used mainly in the production of sulfuric acid. Platinum may replace vanadium in some catalytic processes, but the relative cost of the materials influence their usage.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

The U.S. is by far the world's largest producer of molybdenum. Domestically, only a few companies produce the bulk of output, and therefore these companies possess significant control over market prices. These large producers, traditionally led by Climax Molybdenum Co., publish an industry standard list price for major products which has generally been accepted by smaller producers.

Demand for molybdenum from every sector increased markedly during late 1979 and 1980. This rise in demand outstripped supply and caused major shortages and resulting price increases. In 1982, industry supply responded slowly to falling demand, thus causing oversupply and a rapid decline in prices from the 1980 high. However, depressed demand is not expected to persist. In fact, demand has already increased substantially since the general economic recovery started in 1983.

Table IX-2 presents the price of molybdenum technical-grade oxide for the years 1978-1982 in 1982 dollars. The average price for this period, \$8.36 per pound, will be used in this analysis. This assumption is supported both by expectations of steady growth in demand and by an industry pricing structure which is likely to respond to increases in production cost.

This price has also been used in the analysis of those plants proposed for inclusion in the Molybdenum Acid Plant subcategory. Because the methodologies used to determine impacts in the two subcategories do not differ, this price is applied to these two plants.

2. Capacity Utilization

The capacity utilization of domestic molybdenum-roasting facilities is computed from industry operational capacity and industry production data. These figures are summarized for the 1978-1982 period in Table IX-3. The average capacity utilization rate for this period, 72%, is used for the purposes of our analysis, on the assumption that capacity utilization in a stable market will roughly parallel the average of capacity utilization in periods of over- and undersupply.

Several plants in the study produce high purity metal products for specialty markets. At these plants, molybdenum operations constitute a small percentage of total operations, and capacity and production fluctuate with the volume of orders and with product mix

TABLE IX-2

MOLYBDENUM TECHNICAL-GRADE OXIDE PRICES
(price per pound contained molybdenum)

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	4.86	6.70
1979	6.07	7.69
1980	8.99	10.42
1981	8.50	9.01
1982	7.99	7.99
Average price = \$8.36		

SOURCE: Mineral Facts and Problems, 1980 and
Mineral Commodity Summaries,
U.S. Department of the Interior,
Bureau of Mines, 1983.

TABLE IX-3

MOLYBDENUM CAPACITY UTILIZATION

Year	Production (million pounds)	Capacity (million pounds)	Capacity Utilization (percent)
1978	103	125	82
1979	110	125	88
1980	116	125	93
1981	87	125	70
1982	52	125	<u>42</u>
Average capacity utilization = 72%			

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

decisions. At the facility identified in the Secondary Molybdenum/Vanadium subcategory, similar problems exist with respect to capacity and product mix. Consequently, it is necessary to use the 1982 value of products produced as a proxy for sales at these plants.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the Primary Molybdenum/Rhenium subcategory, nor is it expected to have a significant impact on the two metallurgical acid plants proposed for inclusion in the Metallurgical Acid Plant subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for any plant in this subcategory. No plant is projected to close. In addition, compliance costs for this subcategory are less than 0.5% of production costs under the most stringent treatment option.

Results of the screening test indicate that annual compliance costs exceed 1% of revenues for the one plant identified in the Secondary Molybdenum/Vanadium subcategory. However, closure analysis shows that this plant will not close. Compliance costs for this subcategory are less than 1.5% of production costs under the most stringent treatment option.

CHAPTER X

PRIMARY NICKEL/COBALT AND SECONDARY NICKEL
SUBCATEGORIES

X. PRIMARY NICKEL/COBALT AND SECONDARY NICKEL
SUBCATEGORIES

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

a. Cobalt

Cobalt is usually mined as a byproduct of either nickel or copper. A variety of techniques are used in processing nickel, depending on the type of ore. The ore is first concentrated by crushing, grinding, and flotation. This concentrate is leached with ammoniacal solution and acid is added to precipitate the nickel and other impurities. Cobalt powder is obtained through electrolytic or hydrogen reduction of the remaining solution. Nickel and copper are generally produced as byproducts during cobalt processing.

b. Nickel

Primary nickel is produced in the U.S. from laterite ore and imported matte, and as a byproduct of copper refining. Secondary nickel is recovered from nickel-bearing alloys, stainless and alloy steels, and residues from copper smelters and refineries, foundries, and steel mills.

The laterite ore is first concentrated to yield higher nickel-bearing matte, by smelting and subsequent flotation of the residue. The residue, consisting of high-grade nickel sulfide, is roasted to nickel oxide and reduced to impure nickel by smelting or leaching, and finally refined electrolytically to yield pure nickel metal. Copper and cobalt are produced as byproducts after the nickel sulfide solution is further processed.

2. Description of Plants

a. Cobalt

AMAX Nickel, Inc. operates the only primary cobalt refinery in the U.S., at Braithwaite, Louisiana. However, cobalt operations at AMAX accounted for only a small portion of their total shipments in terms of value. The AMAX plant is also the largest primary producer of nickel in the U.S.

b. Nickel

AMAX Nickel, Inc., at its Braithwaite, Louisiana plant, is the only domestic primary producer of nickel. AMAX extracts nickel metal from laterite ore concentrates. GTE in Warren, Pennsylvania and Huntington Alloys in Huntington, West Virginia have been identified as secondary producers of nickel.

The one primary nickel/cobalt plant has been identified as a direct discharger of effluents. In the secondary nickel subcategory, a zero discharger and an indirect discharger have been identified. The discharging facilities will be analyzed in their respective subcategories.

3. U.S. Production, Consumption, and Trade

a. Cobalt

The U.S. consumes, directly or indirectly, more than one-third of the world's cobalt production. Although the U.S. has extensive domestic cobalt resources, domestic mine production is insignificant. Consequently, domestic industry relies almost entirely on imports, primarily from Zaire and Zambia, for its supply. Table X-1 shows that the recent recession significantly affected U.S. production, consumption, and trade. Between 1980 and 1982, consumption fell by approximately 34%. This decline in demand resulted in a 26% decline in domestic production and a 21% decline in imports.

b. Nickel

Domestic nickel is produced primarily from imported raw materials (44% of 1982 production) and scrap (52%). Of a total 76,903 short tons of nickel produced in 1982, only 3,203 short tons, or 4% of total production, were produced from domestic ore. As shown in Table X-2, this figure represents a substantial decline from the 10,305 tons produced in 1981.

U.S. nickel consumption has decreased steadily in recent years, from a high of 273,000 tons in 1978 to only 198,000 tons in 1982. Nickel imports, while somewhat erratic, have also declined, from 234,352 tons in 1978 to 144,000 tons in 1982. U.S. nickel exports, in the form of refined metal, increased approximately 38% during this period.

TABLE X-1

U.S. COBALT PRODUCTION, CONSUMPTION, AND TRADE

(short tons of cobalt content)

	1978	1979	1980	1981	1982
Production (secondary)	518	585	592	486	436
Consumption	10,182	9,403	8,527	6,266	5,592
Trade -- Imports	9,515	9,999	8,151	7,797	6,435
Trade -- Exports ^a	774	363	292	417	250

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

^aEstimated.

TABLE X-2

U.S. NICKEL PRODUCTION, CONSUMPTION, AND TRADE
(short tons of nickel content)

	1978	1979	1980	1981	1982
Production					
Mine	13,509	15,065	14,653	12,099	400
Refinery (primary)					
Domestic ore	11,298	11,691	11,225	10,305	3,203
Imported matte	26,000	32,500	33,000	38,500	33,700
Refinery (secondary)	44,182	57,404	49,291	52,000	40,000
Consumption	273,000	226,000	206,000	197,000	198,000
Trade -- Imports	234,352	177,205	189,188	200,348	144,000
Trade -- Exports	16,599	23,949	19,463	19,616	23,000

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

4. End Uses and Substitutes

a. Cobalt

Cobalt is used principally in heat- and wear-resistant materials, cutting tools, high-strength materials, permanent magnets, and in various chemical applications. More than 25% of cobalt consumed is processed into non-metallic compounds. Two major uses for cobalt metal are in superalloys used extensively in the aircraft industry, and in turbines. The table below presents a breakdown of cobalt consumption by major end-use markets in 1982.

End-Use Market	% 1982 U.S. Cobalt Consumption
Gas turbine engines	37
Magnetic materials	16
Driers	11
Catalysts	10
Metal cutting and mining tools	7
Other	<u>19</u>
TOTAL	100

The following materials may be substituted for cobalt: nickel, platinum, barium or strontium ferrite, and iron in magnets; tungsten, molybdenum carbide, ceramics, and nickel in machinery; nickel and ceramics in jet engines; nickel in catalysts; and copper, chromium, and manganese in paint. However, such substitutions normally result in a decreased level of performance of these products.

b. Nickel

Nickel's ability to impart corrosion resistance, strength, and specific physical properties in alloys commends its wide use in many producer and consumer goods. More than 90% of nickel consumed in the U.S. is in the form of alloys. Superalloys that resist stress and corrosion at high temperatures account for most of the nickel used in aircraft. Nickel alloys are also commonly used to make stainless and other high-strength, heat-resistant steels such as those used in machinery, construction, and metal products. It is also used as a catalyst in a large range of inorganic chemical reactions. Resistance alloys containing up to 80% nickel account for most of the nickel used in electrical equipment. Some types of batteries use nickel with iron, cadmium, and zinc. The distribution of U.S. nickel consumption in 1982 among major end-markets is reported in the following table.

End-Use Market	% 1982 U.S. Nickel Consumption
Transportation	24
Chemical industry	15
Electrical equipment	11
Construction	9
Fabricated metal products	9
Petroleum	8
Appliances	8
Machinery	8
Other	9
TOTAL	100

With few exceptions, substitutes for nickel would result in increased cost or some sacrifice in the economy or performance of the product. Potential nickel substitutes are aluminum, coated steel, and plastics in the construction and transportation industries; nickel-free specialty steels in the power generating, petrochemical, and petroleum industries; titanium and plastics in severe corrosive applications; and platinum, cobalt, and copper in catalytic uses.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

a. Cobalt

Cobalt is traded mainly in the form of cathodes with a minimum purity of 99.6%. Until the disruption of supplies from Zaire, 90% of all cobalt produced was marketed on a producer price basis. The sudden price rise during 1978-1980 and the subsequent rapid fall, however, have encouraged a very active free market in the metal. Table X-3 presents U.S. prices between 1978-1982. With increasing demands, higher cobalt prices are expected in the near future. An estimate by the Bureau of Mines indicates that the domestic demand for cobalt will increase at an average annual rate of 2.5% through 1990; significant increases are expected in the transportation and industrial machinery sectors. The average price of the 1978-1982 period, \$21.97 per pound, will be used in the analysis.

b. Nickel

Historically, nickel had been produced by a limited number of powerful groups led by International Nickel of Canada, which at one stage had over 80% of the western market. However, the last 10 years

TABLE X-3

COBALT PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	11.53	15.89
1979	24.58	31.15
1980	25.00	28.99
1981	19.73	20.91
1982	12.90	12.90
Average price = \$21.97		

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, December 1983.

have seen dramatic changes in the structure of the industry with the entry of newcomers; International Nickel's share is now less than 35%. The LME is now by far the biggest influence on nickel price, although most of the larger consumers still buy their requirements directly from producers.

As Table X-4 shows, the price of nickel has remained comparatively steady over the last few years. This has been due partly to increased competition from smaller producers and partly to the fall in demand during the current recession. With steady economic recovery, the price of nickel is expected to rise gradually to match the increase in demand. Estimates by the Bureau of Mines indicate that domestic demand will increase at 2.1% per year, from a 1981 base, through 1990. The average price between 1978-1982, \$3.36 per pound, will be used for the purposes of analysis.

2. Capacity Utilization

a. Cobalt

Demand for cobalt has, in general, outstripped supply. Information from the Bureau of Mines indicates that primary producers operated at an average rate of 87% between 1978-1982. Operations are expected to continue at this rate in the near future to satisfy the large demand for cobalt products. This rate is used in the analysis.

b. Nickel

Nickel is vital to many strategic industries. The U.S. nickel industry has operated at fairly high rates of capacity utilization in the past. Agency data and Bureau of Mines sources indicate that nickel metal and ferronickel producers together operated at an average rate of approximately 85% between 1978-1982; this rate has been used in the analysis. Their total capacity has been approximately 54,000 short tons and production has averaged between 40,000-52,000 short tons. The Bureau of Mines estimates that demand for high-strength nickel alloys will rise gradually at an annual rate of 2.1% through 1990. With the economy showing definite signs of improvement, the nickel industry is expected to continue operating at high rates.

TABLE X-4

NICKEL PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	2.08	2.87
1979	2.49	3.16
1980	3.41	3.95
1981	3.43	3.64
1982	3.20	<u>3.20</u>
Average price = \$3.36		

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, December 1983.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the Primary Nickel/Cobalt subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for the one plant identified as a discharger of effluents. This plant is not projected to close. In addition, compliance costs are less than 0.1% of total production costs for this subcategory.

Results of the screening test show that annual compliance costs exceed 1% of revenues for the one discharging plant identified in the Secondary Nickel subcategory. However, closure analysis indicates that this plant will not close. Additionally, compliance costs are less than 3.0% of revenues under the most stringent treatment option.

CHAPTER XI

PRIMARY PRECIOUS METALS/MERCURY AND
SECONDARY PRECIOUS METALS SUBCATEGORIES

XI. PRIMARY PRECIOUS METALS/MERCURY AND SECONDARY PRECIOUS METALS SUBCATEGORIES

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

a. Gold

Gold occurs mainly as a native metal, combined with silver, copper, or other metals. Gold is also associated with iron, silver, arsenic, antimony, and copper sulfides. Weathering and erosion cause gold in free or metallic form to be released from primary deposits and to accumulate as nuggets and grains. In the U.S., about 60% of domestic production comes from gold ores; the remainder is a byproduct of copper or other metal production. Most of the ore is recovered from deep narrow veins or from thin layers called reefs. The remaining ore comes from open pit mining.

Gold is recovered from ore concentrates by leaching it in cyanide solution. Zinc dust is added to the solution to precipitate gold and any silver present in the concentrate. The precipitate is then smelted to oxidize any base metals present and then resmelted in a chlorine atmosphere. The chlorine converts any other impurities present into chlorides, which float on the liquid metal and can be skimmed off to yield commercial grade gold. Further refining can be achieved by electrolysis to produce up to 99.98% pure gold. In the refining of gold from ore, silver and platinum group metals are also recovered.

Secondary gold is recovered from industrial scrap, gold plated materials, or plating solutions. Scrap is dissolved in a strong acid and sulfur dioxide is bubbled through the solution to precipitate gold. Gold may also be dissolved in a cyanide solution and recovered by electrolysis. In the case of recovery from plating bath solutions, zinc or aluminum is added to precipitate gold. The precious metal is again refined electrolytically.

b. Silver

Silver occurs in several minerals. In the U.S., the most common sources of silver are from ores containing gold, lead, copper, or zinc. Most extraction in the U.S. is from tetrahedrite ($\text{Cu}_3(\text{Sb,AS})\text{S}_3$), which is mined by sinking vertical shafts and then excavating the sub-surface deposits.

In the production of primary silver, silver containing ore is first concentrated by a flotation process. This concentrate is smelted to remove base metals which oxidize and form a scum. The partially refined metal is resmelted with chlorine gas and the silver is removed as silver chloride. Silver chloride is then leached with dilute hydrochloric acid, and iron or a ferrous solution is added to precipitate the silver. The crude silver is refined electrolytically to 99.95% to 99.99% purity. Gold and copper are usually recovered in the silver refining process.

Secondary silver is recovered from industrial scrap containing gold and silver, by dissolution of the scrap in acids and precipitation of first gold and then silver. The silver is refined electrolytically to higher purity levels.

c. Platinum-Group Metals

The six metals which comprise the closely related platinum-group metals (PGMs) are platinum, palladium, rhodium, ruthenium, iridium, and osmium. These elements generally occur together and are sometimes associated with gold. Occasionally they are found in coal deposits with nickel and copper. Nickel, copper, cobalt, and gold are common byproducts of platinum mining. However, in most cases the PGMs are byproducts of nickel and copper mining.

The PGMs are recovered from anode slimes during copper or nickel extraction. The anode slimes also contain gold; after precipitation of gold, ammonium chloride is added to the solution to precipitate platinum and palladium. Secondary PGMs are also recovered in a similar manner by first dissolving scrap in aqua regia (if gold is also present) and then selectively precipitating gold, silver, and finally PGMs.

d. Primary Mercury

Mercury deposits occur in many minerals, but the most commonly known is the red sulfide or cinnabar (HgS). It contains about 86.2% mercury and 13.8% sulfur. Cinnabar may either be disseminated in fine-grained rocks or in fissures and cracks of country rocks, or as almost pure cinnabar, sharply separated from the gangue. Mercury ore is mined by both surface and underground methods, though the larger part of the ore has been produced by the latter. The ore is beneficiated by crushing and flotation. The beneficiated ore is heated in retorts or furnaces to liberate the metal as vapor, which when cooled collects as condensed metal. For larger operations, either rotary or multiple-hearth furnaces may be used. The soot may be treated with lime to recover mercury contained in it.

Other non-commercial methods of mercury recovery have also been developed. One method dissolves mercury ore in a solution of sodium sulfide and sodium hydroxide. The mercury is leached, and then recovered as metal by precipitation with aluminum, or by electrolysis. In another process, mercury in the ore is dissolved in a sodium hypochlorite solution. Mercury absorbed in activated carbon, used to treat the solution, is recovered by subsequent heating.

2. Description of Plants

a. Primary Producers

Since gold and silver generally occur together in most ores, producers usually recover both these precious metals as coproducts of ore refining. Producers which recover gold and silver from their ores are the Homestake Mining Company at Lead, South Dakota and Creede, Colorado; Sunshine Mining Company at Kellogg, Idaho and Silver Peak, Nevada; and the Cortez Gold Mines at Cortez, Nevada and Whitehall, Montana. The Homestake Mine at Lead, South Dakota, has accounted for more than 10% of all U.S. gold production.

Gold and silver are also recovered as byproducts of copper refining operations. The Amax Corporation at Carteret, New Jersey; Asarco at Amarillo, Texas and Tacoma, Washington; Duval at Battle Mountain, Nevada; and Kennecott Refineries at Magna, Utah each recover gold and silver as byproducts of their copper refining operations.

The Carlin Gold Mining Company at Carlin, Nevada recovers gold and mercury from a gold-mercury ore; and McDermitt Mine at McDermitt, Nevada recovers mercury from mercury ore.

Of the plants within the scope of the proposed regulations, only one plant is a direct discharger. The other 12 plants are either zero or dry dischargers and are therefore not analyzed further. Because no discharging plant produces mercury, this metal is not discussed further.

b. Secondary Producers

The Agency has identified 48 domestic secondary producers of precious metals. Of the 48 secondary producers, 20 plants consume part or all of their production captively. Most of these plants purchase electronic, jewelry, or dental scrap and refine and realloy it for use in jewelry or dental alloy. Some of the plants engaged in these operations are J.M. Ney, Bloomfield, Connecticut; Martin Metal, Los Angeles, California; Hoover & Strong, Richmond, Virginia; Dentsply,

York, Pennsylvania; Pease & Curren, Warwick, Rhode Island; L.S. Plate & Wire, Woodside, New York; and Handy & Harman, Attleboro, Massachusetts.

Other companies simply melt electronic, jewelry, or dental scrap and form an impure bullion. They then either realloy the metals themselves or send the impure bullion to a refiner for further refining. For instance, the Behr Metals plant at Rockford, Illinois makes a copper-based alloy consisting of gold, silver, and platinum-group metals and sends it to Amax for refining.

There are a few plants which refine mainly platinum-group metals. The Johnson Matthey plant at West Deptford, New Jersey recovers platinum and palladium from various spent catalysts and platinum-containing glasses. Johnson Matthey subsequently uses the platinum and palladium for making automotive catalysts. The Engelhard plant at Newark, New Jersey and the Gemini Industries plant at Santa Ana, California are also engaged in similar operations.

Another class of secondary refiners recovers gold and platinum-group metals for use in making cyanid solutions or plating bath chemicals. The Occidental Chemical Corp. plant at Chatsworth, California recovers gold and PGMs from gold solutions, plated parts, and scrap and uses the metals for making chemical solutions. The Engelhard plant at Anaheim, California recovers gold from electronic scrap and produces both potassium cyanide gold solution and electronic contacts. The Nassau Recycle plant at Staten Island, New York makes gold slats for plating baths.

Twenty plants are secondary refiners. Starting from electronic, dental or jewelry scrap, these plants sell their output without any self consumption or further conversion. A large number of these plants work on a regular "toll" basis for end users from whom they obtain scrap and send back refined precious metals.

There are 3 direct dischargers, 29 indirect dischargers, and 16 zero dischargers of effluents. Secondary silver production is not covered under this regulation and will not be discussed further.

3. U.S. Production, Consumption, and Trade

a. Gold

Secondary gold production accounts for a significant portion of domestic supply. Secondary production was quite stable between 1978-1982. As shown in Table XI-1, while consumption fell 32% from 1978 to

TABLE XI-1

U.S. GOLD PRODUCTION, CONSUMPTION, AND TRADE
(million troy ounces of contained gold)

	1978	1979	1980	1981	1982
Production:					
Mine	1.00	0.96	0.97	1.38	1.44
Refinery (domestic ore)	0.96	0.80	0.77	0.80	0.72
Refinery (imported ore and base bullion)	0.071	0.083	0.014	0.004	0.001
Secondary	3.08	2.88	3.82	3.06	3.02
Consumption	5.10	5.12	3.60	3.50	3.45
Trade -- Imports (refined bullion)	4.45	4.37	4.09	4.16	4.24
Trade -- Exports (refined bullion)	5.02	15.59	4.70	5.24	1.64

SOURCE: Mineral Commodity Profiles and Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, 1983.

1982, secondary production dropped just 2%. Imported ore and base bullion play an insignificant part in the domestic supply of refined production. However, imports of refined bullion continue to be an important source of domestic supply. Since 1978, refined bullion imports have averaged around 4 million troy ounces.

b. Silver

U.S. production, consumption, and trade of silver are significantly affected by movements in the price of silver. As shown in Table XI-2, silver production and exports rose 17.7% and 268.2%, respectively, from 1978 to 1980, following the rise of silver prices to their 1980 record high. Both production and exports then declined 36.8% and 71.6%, respectively, from 1980 to 1982, following the collapse in silver prices.

c. Platinum-Group Metals

U.S. mine production, derived as a byproduct or coproduct of copper refining, forms an insignificant part of the domestic supply of PGMs. As shown in Table XI-3, imported primary metal provides approximately 90% of domestic requirements; the remainder is produced primarily from domestic secondary sources, such as petroleum catalysts, chemical catalysts, glass-fiber bushings, and electronic scrap. Between 1979-1982 consumption fell about 33%, primarily due to slower industrial activity in the automotive and chemical industries, which are major platinum catalyst consumers. This decline in demand had a major impact on imports but little impact on domestic production. In fact, while imports fell 40% over this period, domestic secondary production actually rose 11%.

4. End Uses And Substitutes

a. Gold

In addition to jewelry, gold has many industrial, dental, and defense applications. Of the industrial applications, the most important has been in modern solid-state electronic devices such as miniaturized circuitry connectors and switch contacts. Gold's high conductivity and corrosion resistance are important to these uses. Gold's reflectivity of infrared radiation has led to use as an insulating device in large buildings and spacecraft. Gold has also long been used in dentistry for its non-allergenic and malleable properties. Jewelry and arts, however, continue to be gold's major market. As shown in the table below, a small percentage is also purchased for investment.

TABLE XI-2

U.S. SILVER PRODUCTION CONSUMPTION, AND TRADE

(million troy ounces of contained silver)

	1978	1979	1980	1981	1982
Production ^a	113	124	133	103	84
Consumption	148	131	91	169	144
Trade -- Imports	77	92	79	94	97
Trade -- Exports	22	36	81	28	23

SOURCES: Non-Ferrous Metals Data -- 1982, American Bureau of Metal Statistics.

Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

^aRefined production from ore, concentrates, coins, and old scrap.

TABLE XI-3

U.S. PLATINUM-GROUP METAL
PRODUCTION, CONSUMPTION, AND TRADE
(thousand troy ounces)

	1978	1979	1980	1981	1982
Production					
Mine	8	7	3	6	8
Refined (primary)	10	9	3	7	7
Refined (secondary) ^a	257	309	331	392	343
Consumption	2,260	2,756	2,206	1,921	1,855
Trade -- Imports (refined metal)	2,723	3,311	3,125	2,612	1,976
Trade -- Exports	702	900	765	863	862

SOURCE: Mineral Commodity Profiles and Mineral Industry Surveys,
U.S. Department of the Interior, Bureau of Mines, 1983.

^aToll-refined material is excluded.

End-Use Market	% 1982 U.S. Gold Consumption
Jewelry and arts	61
Industrial (mainly electronic)	29
Dental	9
Small bars (mainly for investment)	<u>1</u>
TOTAL	100

Although no metal or alloy has all of gold's desirable properties, several substitutes have been developed as a result of the high prices of gold in recent years. Platinum and palladium can substitute for gold in many applications, but there still exists established consumer preference for gold. Silver may substitute for gold in electrical end uses, but is less corrosion-resistant.

b. Silver

Silver is critical to the production of many manufactured products. It provides high electrical conductivity, resistance to oxidation, and strength at a wide range of temperatures. Silver consumption in many end uses is based upon the superior performance of the metal or one of its compounds. Silver consumption by end-use is presented below.

End-Use Market	% 1982 U.S. Silver Consumption
Photography	39
Electrical and electronic components	29
Sterlingware and jewelry	14
Brazing alloys and solders	7
Other	<u>11</u>
TOTAL	100

Silver's metallurgical properties and consumer appeal limit substitution in most uses. However, technological developments in the photography industry have led to a minor decline in silver usage in that industry.

c. Platinum-Group Metals

PGMs are valued for their refractory quality, their chemical inertness at high temperatures, and their excellent catalytic activity. These properties make PGMs particularly suitable for a variety of industrial uses. The table below shows that the automotive industry is the principal consumer, using PGMs as catalysts to control automobile exhaust emissions. PGMs are also used in electrical contacts and relays in telephone systems. PGM catalysts are used by the chemical industry to produce acids and organic chemicals, and to upgrade the octane rating of gasoline. Because of their high prices, PGMs are used only where well-justified both technically and economically.

End-Use Market	% 1982 U.S. PGM Consumption
Automotive	33
Electrical	28
Chemical	15
Dental supplies	9
Other	15
TOTAL	100

In automotive catalysts, platinum, palladium, and rhodium have had no competition from substitutes in recent years. Molybdenum and chromium can substitute for PGMs in petroleum refining, but only by sacrificing yield and catalyst life. In recent years, the combination of rhenium with platinum in petroleum-reforming catalysts has resulted in a significant improvement in performance and durability. Silver and gold often substitute for platinum and palladium in electrical end uses. For PGM alloys requiring wear resistance, such as electrical contact points, ruthenium has been used as a more effective and cheaper hardening agent than iridium.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Precious metals are generally sold in their pure form. The major producers publish an official price for virgin, unwrought ingots with a minimum purity of 99.5%. This price is applicable to industrial accounts and long-term purchases. The dealers' price, as quoted by U.S. producers, is applicable to spot purchases. Prices may also be affected by premiums for higher purity, different shapes, long-distance delivery, speculation, and exchange-rate fluctuations. The free market prices of gold and platinum usually follow each other upward or downward. Tables

XI-4 and XI-5 show that prices for refined gold, silver, platinum, and palladium have fallen in recent years due to lower demand for these metals. However, with the growth of the economy, demand for these metals is expected to increase, resulting in higher prices. Average prices over the 1978-1982 period will be used in this analysis.

A small part of the market is concerned with the trading of unrefined metals by small secondary producers who sell their product on a toll or non-toll basis. Prices for such inter-company transfers are not quoted in the market. Therefore, information supplied by these plants regarding 1982 revenues and production levels has been used to analyze the impact of environmental regulations on these producers.

2. Capacity Utilization

Capacity utilization rates for gold, silver, and PGMs have fallen significantly since 1980. However, these conditions are not expected to persist. Platinum-group metals are critical to industry because of their extraordinary physical and chemical properties. The Bureau of Mines estimates that the domestic production of platinum and palladium will double in the near future as a result of increasing demand for automotive catalytic converters. Steady demand growth for gold is expected in electronics, telecommunications, robotics, and computers. Steady demand for silver is also expected in these electronics-related fields. Therefore, plants producing these precious metals are expected to generate higher revenues in the near future with higher prices and higher capacity utilization rates. Tables XI-6 and XI-7 list the capacity utilization rates between 1978-1982 for gold, silver, and PGMs. The average rates, 77% for gold plants, 70% for silver plants, and 72% for PGMs, have been used for this analysis. For those secondary producers who trade unrefined metals, information supplied on capacity utilization in 1982 has been used in this analysis.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the Primary Precious Metals/Primary Mercury subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for the one plant identified as a discharger of effluents. This plant is not projected to close. Results of the screening test indicate that annual compliance costs exceed 1% of revenues for one of the 32 plants incurring costs in the Secondary Precious Metals subcategory. The closure analysis identifies this plant as a potential closure candidate. However, compliance costs are less than 0.25% of total production costs for both subcategories under the most stringent treatment option.

TABLE XI-4

U.S. GOLD, PLATINUM, AND PALLADIUM PRICES
(dollars per troy ounce)

Year	Gold		Platinum		Palladium	
	Actual	1982 Dollars	Actual	1982 Dollars	Actual	1982 Dollars
1978	194	266	237	327	71	98
1979	308	390	352	446	113	143
1980	613	710	439	509	214	248
1981	460	487	475	504	130	138
1982	376	<u>376</u>	475	<u>475</u>	110	<u>110</u>
Average price =		\$446		\$452		\$147

SOURCE: Mineral Commodity Profiles, U.S. Department of the Interior, Bureau of Mines, 1983.

TABLE XI-5

U.S. SILVER PRICES

(dollars per troy ounce)

Year	Actual	1982 Dollars
1978	5.40	7.44
1979	11.09	14.06
1980	20.63	23.92
1981	10.52	11.15
1982	<u>7.95</u>	<u>7.95</u>
Average price = \$12.90		

SOURCE: Non-Ferrous Metals Data -- 1982,
American Bureau of Metal
Statistics, Inc.

TABLE XI-6

GOLD AND PLATINUM-GROUP METALS
CAPACITY UTILIZATION RATES

Year	Gold	Platinum-Group Metals
1978	86%	80%
1979	78%	80%
1980	96%	100%
1981	64%	50%
1982	<u>53%</u>	<u>50%</u>
Average =	77%	72%

SOURCE: Personal communication,
U.S. Department of the
Interior, Bureau of
Mines, January 1984.

TABLE XI-7

CAPACITY UTILIZATION -- SILVER

Year	Production ^a (million troy ounces)	Capacity (million troy ounces)	Capacity Utilization (%)
1978	113	160	71
1979	124	160	78
1980	133	160	83
1981	103	160	64
1982	84	160	53
Average capacity utilization = 70%			

SOURCE: Production data -- Non-Ferrous Metals Data -- 1982, American Bureau of Metal Statistics, Inc., and Mineral Commodity Profiles, U.S. Department of the Interior, Bureau of Mines, 1983.

Capacity data -- Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

^aRefined production from ore, concentrates, coins, and old scrap.

CHAPTER XII

PRIMARY RARE-EARTH METALS SUBCATEGORY

XII. PRIMARY RARE-EARTH METALS SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

The rare-earth minerals group consists of 16 chemically similar elements, which generally occur together in various ore deposits. Bastnasite and monazite are the principal raw sources from which the rare-earth materials are obtained. Bastnasite is the major source for the cerium subgroup elements such as lanthanum, samarium, and neodymium (the light subgroup). Since 1979, bastnasite has accounted for more than 50% of the world production of rare-earths. Monazite is the principal source of the heavy or yttrium subgroup elements such as gadolinium, terbium, and dyspromium. Monazite has certain production limitations because thorium and other radioactive components are often associated with the mineral and are produced as byproducts.

The extraction of rare-earth metals is achieved by first converting the oxides present in the ore into chlorides and then reducing the chlorides electrolytically to yield rare-earth metals. The concentrates are converted to chlorides by leaching with hydrochloric acid; next, the concentrates are fused and electrolyzed in a graphite-lined iron cell to produce the rare-earth metals and chlorine. Carbon monoxide and carbon dioxide are produced as byproducts.

Rare-earth minerals are produced in various forms and combinations: as chlorides, as oxide metals, individually, as "mischmetal" (the proportion of each metal in mischmetal is the same as the proportion in ore), and as mixtures of compounds and metals. The currently proposed regulations cover only the electrolytic reduction of the rare-earth chlorides (REC) to the rare-earth metals (REM).

2. Description of Plants

The four plants identified in this subcategory are Ronson in Newark, New Jersey; Remacor, in West Pittsburgh, Pennsylvania; Molycorp, Inc. in Washington, Pennsylvania; and Research Chemicals in Phoenix, Arizona. Two of these facilities use a process that produces no wastewater.

The two discharging plants recover rare-earth metals by electrolysis of the fused chloride, which is an intermediate product in the extraction of rare-earth metals from their ores. One plant imports

most of the rare-earth chlorides required to manufacture rare-earth metals. This plant also produces alloys for use in flints and other industrial and mining purposes, and is an indirect discharger of effluents. The other plant is a direct discharger.

3. U.S. Production, Consumption, and Trade

The U.S. is the world's principal producer and consumer of rare-earth metals, and is a major exporter of rare-earth concentrate and compounds. Domestic consumption in 1982 was estimated at 21,500 tons, 18,500 tons of which was to be supplied largely by domestic production. Table XII-1 shows net increases in all categories except exports of ore and concentrate, which declined approximately 54%, from 6,452 short tons to 3,000 short tons, between 1978-1982.

4. End Uses and Substitutes

Industrial applications of the rare-earth metals have increased markedly in recent years, and the usage pattern of these elements has changed radically. Although traditional uses for lighter flints and carbons, polishing compounds, and glass-ceramic additives continue to constitute significant markets, the manufacture of catalysts for petroleum refining and use in ductile iron and steel are currently the major markets for rare-earth metals.

The table below represents the percentage of rare-earth metals used by individual industries in 1982.

End-Use Market	% 1982 U.S. Rare-Earth Metal Consumption
Petroleum catalysts	43
Metallurgical	34
Ceramics and glass	21
Other	<u>2</u>
TOTAL	100

Substitutes are available for the rare-earth metals, but they are generally significantly less effective. Arsenic and selenium perform similar functions in the ceramics and glass industry; rouge replaces the metals in polishing compounds; iron and calcium fluoride substitute in carbon-arc electrodes; boron may be substituted in thermal neutron absorbers; and palladium performs as a catalyst in petroleum refining.

TABLE XII-1

U.S. RARE-EARTH METALS
PRODUCTION, CONSUMPTION, AND TRADE
(short tons of rare-earth oxide)

	1978	1979	1980	1981	1982a
Production	15,595	18,205	17,622	18,830	18,500
Consumption	17,400	17,600	20,000	22,100	21,500
Trade -- Imports					
Monazite	4,241	3,812	3,121	4,528	4,300
Metals, alloys, oxides and compounds	1,766	1,107	1,790	1,798	2,300
Trade -- Exports					
Ore and concentrate	6,452	4,777	5,226	5,573	3,000
Ferrocerium and pyrophoric alloy	17	37	15	10	30

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

^aEstimated.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Trade in rare-earth materials involves a wide variety of products ranging from concentrates and intermediate production compounds to high-purity compounds and metals; hence, no single price exists for rare-earth minerals. Monazite concentrates are generally sold directly to processors. Bastnasite commands a higher price, because it has a more useful mix of rare-earth elements. In some applications, bastnasite concentrates can be used directly without intermediate treatment.

The price of an element depends on its grade and purity designation. No historical price information is available for rare-earth metals. Prices quoted for most of the rare-earth elements in 1982, though the same as in 1981, had fallen considerably from the 1979 levels. Prices for high-purity oxides in 1981 and 1982 ranged from \$7.00 per pound for lanthanum to \$900 per pound for europium. Mischmetal, which is a mixture of rare-earth elements in metallic form, was quoted at \$5.60 per pound through 1981 and 1982. Because the two plants covered by the proposed regulations produce mainly mischmetal, this mischmetal price has been used to analyze these plants.

2. Capacity Utilization

Rare-earth metals are in abundant supply in the United States. Improved knowledge of rare-earth properties may lead to new industrial applications. Therefore, the demand pattern is expected to continue to shift from established uses, such as petroleum refining, to new uses such as steel additives and phosphors. Special mixtures, such as those used in x-ray screens, fluorescent lamps, permanent magnets, and electronics are becoming increasingly popular. The Agency's data indicate that most of the plants operated at approximately 50% of their capacity during the 1982 recession. For the purposes of this analysis, it has been assumed that the plants will continue operating during the impact period at existing capacity utilization levels.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the rare-earth subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for any plant in the subcategory. No plant is expected to close. In addition, compliance costs for this subcategory are less than 0.7% of production costs under the most stringent treatment option.

CHAPTER XIII

SECONDARY TANTALUM SUBCATEGORY

XIII. SECONDARY TANTALUM SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Tantalum mineral concentrates and tin slags are the predominant feed materials for production of tantalum metal and compounds. Both raw materials usually contain recoverable amounts of columbium as well. Many mineral concentrates contain 50% or more of the combined pentoxides, Ta_2O_5 and Cb_2O_5 , the Ta:Cb ratio depending on the deposit. Tin slags generally contain more Ta_2O_5 than Cb_2O_5 .

In the U.S., most tantalum production is from secondary sources, starting with tantalum scrap, or tantalum-bearing sludge. Tantalum is recovered from scrap by leaching it with acid, which dissolves other metals like nickel and impurities, to leave behind impure tantalum. It is then refined by washing, filtering, and cleaning the residue again in acid and finally drying it to obtain pure tantalum.

Metallic forms of tantalum are produced chiefly in unalloyed form or alloyed with up to 10% tungsten. Tantalum powder of 99.9% purity is also produced.

2. Description of Plants

Three plants in the U.S. recover secondary tantalum. They are GTE Products Corp. in Towanda, Pennsylvania, Kennametal, Inc. in Latrobe, Pennsylvania, and Texas Instruments in Attleboro, Massachusetts. The recovery process involves leaching with acid to dissolve other metals and impurities and finally washing and cleaning the residue to recover tantalum. All three plants are direct dischargers.

3. U.S. Production, Consumption, and Trade

Tantalum raw materials have never been produced in the U.S. in significant quantities. Domestic tantalum deposits located in numerous pegmatites and placer deposits in Arizona, Colorado, North Carolina, South Dakota, Utah, New Mexico, and Alaska are low in grade, and therefore are not economical to mine. Thus, the U.S. has historically relied on imports of tantalum concentrates and tin slags from Thailand, Canada, Malaysia, and Brazil for its primary tantalum supply. Table

XIII-1 shows that consumption of raw materials, imports, and exports all rose from 1978 to 1981; however, the 1981-1982 recession caused precipitous declines in all categories. The 1982 estimate of 800,000 pounds of raw materials consumed is approximately 54% below the 1979 level; imports declined from the 1980 high of 2.3 million pounds to an estimated 1.2 million pounds in 1982; and exports, which had risen to substantial levels, are estimated in 1982 to rise 82% above the 1981 level of 401,000 pounds, to 732,000 pounds.

4. End Uses and Substitutes

Tantalum is used primarily by the electronics industry in the manufacture of capacitors. Tantalum carbide, usually mixed with other metal carbides such as tungsten, titanium, and columbium, is used in metalworking machinery, including cutting tools, farm tools, turning and boring tools, and wear-resistant parts. A third application for tantalum is in chemical processing equipment. Aerospace and other transportation applications utilize tantalum for its high melting point, strength at high temperatures, and corrosion resistance. Other uses such as nuclear reactors and optical glass account for less than 1% of total use. The table below presents the percentage breakdown of tantalum use by its three major markets.

End-Use Market	% 1982 U.S. Tantalum Consumption
Electronic components	70
Machinery	22
Transportation	8
TOTAL	<u>100</u>

Other metals or minerals may be substituted for tantalum, but at a performance or economic penalty. Aluminum and ceramics compete with tantalum for use in capacitors. Silicon, germanium, selenium, and other metals may be substituted in other electronic uses. Columbium carbide may be used in some machinery, and glass, platinum, titanium, and zirconium may substitute for tantalum's corrosion resistance. The platinum-group metals, columbium, molybdenum, and tungsten, may be substituted in high temperature applications.

TABLE XIII-1

U.S. TANTALUM PRODUCTION, CONSUMPTION, AND TRADE
(thousand pounds of tantalum content)

	1978	1979	1980	1981	1982 ^a
Production -- Primary Metal ^b	974	--	--	--	--
Consumption -- Raw Materials	1,571	1,740	1,863	1,269	800
Consumption -- Tantalum Metal ^b	978	--	--	--	--
Trade -- Imports ^c	1,409	1,914	2,327	1,612	1,160
Trade -- Exports ^d	961	1,051	1,243	401	732

SOURCE: Minerals Yearbook, U.S. Department of the Interior, Bureau of Mines, 1982.

^aEstimated.

^bNo data are available for these categories between 1979-1982.

^cMineral concentrate, tantalum metal and tantalum-bearing alloys, and tin slags for consumption.

^dTantalum ore and concentrate, tantalum metal, compounds, alloys and alloy-powders. Also includes re-exports.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Tantalum is produced in a wide variety of forms, such as powder, rod, sheet, and carbide. Prices have historically fluctuated with variations in tantalum supply. Domestic price quotations for these products have generally covered a rather broad range. The average price for tantalum carbide between 1978 and 1982 has been approximately \$120 per pound in constant 1982 dollars. During the same period, tantalum metal prices have averaged \$157 per pound, and those of tantalum concentrates have averaged around \$90 per pound. Tantalum product prices, after rising rapidly between 1978 and 1980, declined substantially by the end of 1982. The average prices between 1978 and 1982 represent the prices expected in a normal year. The increase in demand in the near future is expected to support the average prices. Therefore, the average prices have been used to study the impact of these regulations.

2. Capacity Utilization

The United States has been a significant producer of tantalum metal and compounds. Capacitors and converted carbides -- the two most important consuming sectors -- are expected to grow in the near future. Other new applications of tantalum are expected to be of a specialized nature. Based on the 1981 trend value, the Bureau of Mines estimates that demand will increase at an annual rate of about 3.1% through 1990. Industry sources indicate that most of the plants operated at approximately 45%-50% of their capacity in 1982. With technological advances promising to reduce the electrical energy consumption for the melting and purification of tantalum metal and expectations of price stability in the near future, it is anticipated that the industry shall be gradually able to operate at higher rates. For purposes of the analysis, however, it has been assumed that these plants will operate at 50% of their capacity.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the secondary tantalum subcategory. Results of the screening test show that annual compliance costs do not exceed 1% of revenues for any plant in the subcategory. No plant is projected to close. In addition, compliance costs for this subcategory are less than 0.2% of production costs under the most stringent treatment option.

CHAPTER XIV

PRIMARY AND SECONDARY TIN SUBCATEGORY

XIV. PRIMARY AND SECONDARY TIN SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Cassiterite (SnO_2) is the principal ore from which primary tin is extracted. Cassiterite in placer deposits is fairly coarse-grained and recoveries range from 90% for gravel pump mines to 95% for dredging operations. Cassiterite is reduced to tin by heating with carbon at 1200-1300 degrees centigrade. The impure tin is then refined by electrolytic methods.

Most secondary tin is recovered from bronze and brass, solders, and other alloys. The recovery of secondary tin from tin-plated steel scrap is known as "detinning," and is achieved by removing the tin from steel by dissolving it in chemicals and then by electrolytic separation to yield tin, tin dross, and tin mud. The tin dross contains approximately 80% tin; the tin mud contains about 5% tin. Tin dross and tin mud are usually sold to primary tin smelters for further recovery of tin.

Tin metal is cast and sold as bars, ingots, or slabs. There are several grades of tin available, ranging from 99% to 99.99% purity, depending on end use.

2. Description of Plants

Domestic mine production of tin provides only a small fraction of the domestic tin requirement. Primary tin was produced by only one company, Associated Metals and Minerals Corporation, in the U.S. in 1982. The company's plant in Texas City, Texas produces tin from a stockpile of tin residues and slags, imported tin concentrates, and secondary materials.

Secondary tin is manufactured by detinning plants which use tin-plated steel scrap as raw material. Most of these plants use the tin captively to make chemicals and tin anodes. Proler International and Vulcan Materials together have eight plants engaged in detinning operations. Of the twelve plants within the scope of this regulation, seven are zero dischargers, three are direct dischargers, and two are indirect dischargers.

3. U.S. Production, Consumption, and Trade

Mine production of tin in the U.S. is negligible; small quantities of tin concentrates have been produced from placer deposits in Alaska and as a byproduct of molybdenum mining in Colorado. However, the U.S. continues to be the world's largest producer of secondary tin. About 14,000 tons of tin were recycled in 1982 -- 11,000 tons from old scrap, and 3,000 tons from new scrap. The U.S. imports virtually all primary tin to meet its requirements. Metal imports are the major source of domestic supply. Tin metal imports in 1982 were approximately 56% of reported consumption and came mainly from China, Malaysia, Thailand, and Indonesia. Consumption of both primary and secondary tin has been on the decline since 1979 because of the general economic slowdown that has affected most usage categories. Consumption in 1982 was approximately 21% lower than the 1979 levels. Exports in 1982 declined by approximately 5% from the 1981 levels. Table XIV-1 presents domestic tin production, consumption, and trade information.

4. End Uses and Substitutes

Tin has widely diverse applications. Tin consumption in the United States has for several decades been dominated by tin plate and tin solder. Primary tin, which comes directly from domestic or foreign mine sources, satisfies most of the annual domestic requirements. The important end-use markets for tin are listed below. Cans and containers continue to be the primary end-uses of tin plate. The electrical, construction, and machinery sectors use tin alloys. The largest single use of tin in machinery is as a constituent metal of brass and bronze, often found in bearings, fittings, castings, and stampings.

End-Use Market	% 1982 U.S. Tin Consumption
Cans and containers	25
Electrical	17
Construction	13
Transportation	13
Other	32
TOTAL	100

Aluminum is the most effective substitute for tin plate in its traditional container markets. Non-metallic substances, copper, and aluminum compete with tin in construction uses. Although no satisfactory substitute exists for tin in solder, it is possible to lower the tin content in some applications by increasing the lead or antimony content.

TABLE XIV-1

U.S. TIN PRODUCTION, CONSUMPTION, AND TRADE
(metric tons of tin content)

	1978	1979	1980	1981	1982
Production					
Smelter	5,900	4,600	3,000	2,000	3,500
Secondary	21,100	21,493	18,638	15,438	14,283
Consumption					
Primary	48,403	49,496	44,342	40,229	36,194
Secondary	13,128	12,969	12,020	14,144	13,276
Trade -- Imports					
Metal	46,776	48,355	45,982	45,874	27,939
Ore	3,873	4,529	840	232	1,961
Trade -- Exports (ingots, pigs, bars)	4,692	3,417	4,294	6,080	5,769

SOURCE: Mineral Commodity Summaries and Mineral Industry Surveys,
U.S. Department of the Interior, Bureau of Mines, 1983.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Tin prices are subject to an international agreement between producing and consuming nations. The agreement seeks to secure a long-term balance between production and consumption and to avoid severe short-term price fluctuations. Because Southeast Asia produces the majority of tin, the Penang market in Malaysia generally establishes the world tin price. The Penang market price is determined daily by comparing bids from dealers and consumers. Other principal quotations are those of the London Metal Exchange (LME) and the New York market, both of which offer cash and forward metal prices.

Table XIV-2 reports the net decrease in U.S. tin prices (expressed in 1982 dollars) from \$8.68 in 1978 to \$6.54 in 1982. The decline has occurred mainly as a result of the recent recession and the growth of substitutes. The general economic slowdown has affected most usage categories. However, demand for tin is expected to stabilize because of the price advantage over aluminum and steel. The average price of tin between 1978-1982, \$8.47, is used in this analysis.

2. Capacity Utilization

Historical information on capacity utilization rates for the tin industry are not publicly available. Plant information on production and capacity indicates that the industry operated at an overall capacity utilization rate of 66% in 1982. The major user of tin is still the canning industry. However, tin plate has lost substantial ground to aluminum in this traditional market. Alternative materials have been a significant factor in the downward trend in domestic tin consumption in the past two decades. Therefore, although the economy is expected to recover in the near future, it is assumed, for the purposes of this analysis, that the tin plants will continue operating at the 1982 capacity utilization level of 66%.

C. IMPACT ASSESSMENT

Results of the screening test show that annual compliance costs exceed 1% of revenues for four of the five plants subject to this regulation. Of these four plants, the closure analysis identifies three as potential plant closure candidates and one as a potential line closure candidate. However, compliance costs for this subcategory as a whole are less than 0.8% of total production costs. A more detailed discussion of the closure analysis can be found in Chapter XXII--Economic Impacts.

TABLE XIV-2

TIN PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	6.30	8.68
1979	7.54	9.56
1980	8.46	9.81
1981	7.33	7.77
1982	6.54	6.54
	Average price = \$8.47	

SOURCE: Mineral Commodity Summaries and Mineral Industry Surveys,
U.S. Department of the Interior,
Bureau of Mines, 1983.

CHAPTER XV

PRIMARY AND SECONDARY TITANIUM SUBCATEGORY

XV. PRIMARY AND SECONDARY TITANIUM SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

The primary mineral sources of titanium products are rutile and ilmenite. Rutile is generally preferred for most applications because of its much higher titanium dioxide content. In fact, it is the only titanium raw material used for metal production in market economy countries. However, rutile is far less common than ilmenite. Thus, the combined conditions of high demand and limited supply have led to production of a synthetic rutile which is made from ilmenite.

Titanium tetrachloride is the intermediate product used to make titanium metal. Titanium tetrachloride is produced by a chloride process which uses rutile or synthetic rutile as its raw material. Sponge metal is commonly produced by reducing purified titanium tetrachloride with magnesium or sodium under an inert gas atmosphere. The sponge can be compacted, usually with some scrap additions, and then made into titanium ingot by vacuum-arc-melting operations.

2. Description of Plants

Eight major plants produced titanium metal in the U.S. during 1982. Of these eight plants, one is a zero discharger, one employs a dry process, two are indirect dischargers, and four are direct dischargers of effluents. The plants can be classified by processing characteristics into three main categories.

The first category consists of those plants producing titanium from titanium dioxide. There are four plants in this category. They are International Titanium in Moses Lake, Washington; Kennametal, Inc. in Latrobe, Pennsylvania; Morton Thiokol in Beverly, Massachusetts; and Timet in Henderson, Nevada. The Kennametal plant actually manufactures titanium carbide and the titanium operations represent only a small portion of total plant operations. Because this plant produces no wastewater, it will not be analyzed further. The Timet plant uses captively all titanium it manufactures. The Morton Thiokol plant, in addition to producing titanium, manufactures large amounts of zirconium using similar facilities and processes.

The second category consists of those plants which process titanium from titanium tetrachloride. These plants are Oregon Metallurgical Corp. in Albany, Oregon; RMI Company in Ashtabula, Ohio; and Teledyne Wah Chang Albany, in Albany, Oregon. These plants purchase titanium tetrachloride from primary manufacturers and recover titanium through a reduction process. Each of these plants uses all or part of the titanium produced for captive consumption.

The third category consists of producers from scrap and sponge. The Lawrence Aviation Industries plant in Port Jefferson Station, New York falls into this class. This plant is a zero discharger and will not be analyzed further.

Two types of plants, Level A and Level B, have been identified in this subcategory (see Chapter II). One of the indirect dischargers has been identified as a Level A plant. The Agency has considered the possibility that the Level A plant may at some point engage in Level B processes and therefore be subject to Level B limitations. The impacts of these limitations have been estimated and are discussed in Chapter XXV--Limitations of the Analysis.

3. U.S. Production, Consumption, and Trade

The U.S. is one of the world's largest titanium-producing nations, accounting for about 27% of the world's sponge metal production in 1981. While domestic mines supply over half of the U.S. requirement for titanium in ilmenite and slag, rutile requirements are met predominantly by imports from Australia. The declines in 1982 metal production and consumption, which are shown in Table XV-1, were due primarily to reductions in commercial aircraft programs. Titanium sponge and rutile are both purchased by the government for stockpiling.

4. End Uses and Substitutes

Only about 5% of the world's annual production of titanium minerals goes to make titanium metal. The other 95% is used primarily to make white titanium dioxide pigment. The manufacture of titanium dioxide pigment is not covered by this regulation. In recent years, about 60% of U.S. metal consumption has been in aerospace applications, most notably in jet engines, airframes, and missiles. These applications demand titanium's high strength-to-weight ratio and resistance to heat. Industrial uses in surface condensers, chemical processing, water desalination, and marine applications rely on titanium's high corrosion resistance. The table below presents the breakdown of consumption by end-use market.

TABLE XV-1

U.S. TITANIUM METAL PRODUCTION, CONSUMPTION, AND TRADE

(short tons)

	1978	1979	1980	1981	1982
Production ^a (sponge metal)	17,600	21,100	22,500	26,400	15,600
Consumption (sponge metal)	19,854	23,937	26,943	31,599	17,328
Trade -- Imports (sponge metal)	1,476	2,488	4,777	6,490	1,354
Trade -- Exports (mainly scrap)	7,789	8,602	8,880	9,644	8,096

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

^aCalculated production = reported consumption minus imports plus exports minus beginning inventories plus ending inventories.

End-Use Market	% 1982 U.S. Titanium Metal Consumption
Aerospace applications	60
Industrial uses	20
Additions to steel and other alloys	<u>20</u>
TOTAL	100

Titanium metal is selected over other materials in aerospace construction on a performance, not an economic, basis. Some high-strength, low-alloy steel, aluminum, or other metals may be substituted, but generally require redesigning and may result in lower performance. Nickel steels are to some extent competitive. Stainless steel, Hastelloy, 90-copper-10 nickel, and certain nonmetals may be used to replace titanium's corrosion resistance properties, but are often more expensive.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Unprecedented demand for commercial aircraft in 1980 spurred titanium sponge prices to the record high level reported in Table XV-2. However, after an 80% rise in price from 1978 to 1980, prices fell by 32% in 1982 following a severe downturn in the same commercial aircraft market. Demand from the military sector was a mitigating factor over this period as purchases for fighter aircraft programs continued. The average price over the 1978-1982 period, \$6.27 per pound, will be used in the analysis.

2. Capacity Utilization

Capacity utilization is computed from industry capacity and production data. These figures are summarized for the 1978-1982 period in Table XV-3. Because manufacturers anticipated a greater demand for titanium, industry capacity expanded almost 43% between 1979-1982. Additions to capacity satisfied a growing demand until 1982, when severe cutbacks in commercial aircraft production reduced utilization rates to

TABLE XV-2

TITANIUM SPONGE METAL PRICES

Year	Average Annual Price, Dollars per Pound	
	Actual	1982 Dollars
1978	3.28	4.52
1979	3.98	5.04
1980	7.02	8.14
1981	7.65	8.11
1982	5.55	5.55
Average price = \$6.27		

SOURCE: Mineral Commodity Summaries, U.S.
Department of the Interior, Bureau of
Mines, 1983.

TABLE XV-3

TITANIUM SPONGE METAL - CAPACITY UTILIZATION

Year	Production ^a (short tons)	Capacity (short tons)	Capacity Utilization (%)
1978	17,600	23,000	77
1979	21,100	23,000	92
1980	22,500	28,000	80
1981	26,400	31,000	85
1982	15,600	33,000	47
Average capacity utilization = 76%			

SOURCE: Production data -- Mineral Commodity Summaries and Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, 1983.

Capacity data -- Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

^aCalculated production = reported consumption minus imports plus exports minus beginning inventories plus ending inventories.

below 50%. However, recovery in the commercial aircraft and chemical-processing industries is expected to boost activity to previous high levels. Therefore, the average capacity utilization rate for the 1978-1982 period, 76%, will be used in the following analysis.

Titanium operations often coexist with zirconium operations due to processing similarities. At such plants, titanium production usually represents a lesser part of total operation, and capacity for titanium production fluctuates with product-mix decisions. Because capacity is variable in these operations, the reported 1982 value of production is used as a proxy for sales.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the titanium subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for one plant in the subcategory. However, closure analysis indicates that this plant will not close. In addition, compliance costs for this subcategory are less than 0.6% of production costs under the most stringent treatment option.

CHAPTER XVI

SECONDARY TUNGSTEN/COBALT SUBCATEGORY

XVI. SECONDARY TUNGSTEN/COBALT SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Secondary tungsten metal is recovered from different scrap sources, including wire, hardfacing materials, and various other metal products. Scrap tungsten is first combined with either sodium nitrate or sodium sulfate to produce an intermediate sodium tungsten compound. Calcium chloride is then added to form calcium tungstate, which is leached in hydrochloric acid to yield tungstic acid. The tungstic acid is dissolved in an ammonia solution to produce ammonium paratungstate (APT). APT is a major tungsten intermediate and is traded as such. Tungsten metal powder is obtained by reducing APT with hydrogen. Roughly two-thirds of the metal powder produced domestically is converted to tungsten carbide powder.

The facilities which perform these operations are generally equipped to operate on either primary tungsten ore or tungsten scrap and commonly do so using separate runs. The end products are identical and have equal value regardless of the source. Therefore, in the following discussions of price, production, and capacity, the distinction between primary and secondary is not made.

Secondary cobalt is recovered from tungsten carbide scrap by leaching with acid and precipitation with ammonia. The resulting ammonium cobalt complex is washed with acid; sodium hydroxide is added to precipitate cobalt hydroxide. Cobalt is recovered from the hydroxide by reduction with hydrogen.

2. Description of Plants

The five plants identified in this subcategory are GTE Products in Towanda, Pennsylvania; Kennametal in Latrobe, Pennsylvania; Li Tungsten in Glen Cove, New York; GTE Specialty Metals in Warren, Pennsylvania; and Metec in Winslow, New Jersey. Of the five, four are direct dischargers of effluent waste. One plant produces no wastewater. All four dischargers produce tungsten products. Two also recovered cobalt and tungsten carbide from cemented carbide scrap.

3. U.S. Production, Consumption, and Trade

During 1981, the U.S. tungsten industry reached an all-time high in production. Production and consumption figures are presented in Table XVI-1. Demand for tungsten, primarily in the form of carbide powder, extended well into the recession because tungsten has applications in so many industries. However, in 1982, metal powder production and tungsten consumption declined 32% and 35% respectively. Imports and exports of both metal and carbide powder have been negligible and are usually in the form of specialty grades. The U.S. government stockpiles various forms of tungsten for defense purposes.

Cobalt production, consumption, and trade are discussed in the primary cobalt/nickel and secondary nickel chapters.

4. End Uses and Substitutes

About two-thirds of the tungsten metal powder produced domestically is converted to tungsten carbide and consumed in that form. The extreme hardness of tungsten carbide at high temperatures makes it desirable for use where intense wear, abrasion, heat, and high speed are critical factors. It is used in a variety of industrial applications, especially as a coating for both machine tool cutting edges and forming and shaping dies. About one-third of the tungsten powder produced is used directly in electronics, lighting filaments, counterweights, and armor-piercing shells.

Tungsten's widespread availability, low cost, and physical properties have precluded most substitution. However, titanium, tantalum, and columbium carbides can be substituted for tungsten in some wear-resistant applications. Slight reductions in use may result from improvements in coating techniques, which would extend tool lives and slow replacement.

A description of cobalt's end uses and substitutes can be found in the primary cobalt/nickel and secondary nickel chapters.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

List prices for tungsten metal powder have remained remarkably stable over the last five years, despite fluctuations in raw material costs. Table XVI-2 presents price ranges for the 1978-1982 period.

TABLE XVI-1

U.S. TUNGSTEN PRODUCTION AND CONSUMPTION
(thousand pounds of tungsten content)

	1978	1979	1980	1981	1982 ^a
Production (metal powder)	16,548	18,426	18,116	19,754	13,425
Consumption (concentrate, scrap, metal)	22,353	23,793	21,784	22,767	14,800

SOURCE: Production data -- Personal communication, U.S. Department of the Interior, Bureau of Mines, December 1983.

Consumption data -- Mineral Commodity Summaries, U.S. Department of the Interior, Bureau of Mines, 1983.

^aEstimated.

TABLE XVI-2

TUNGSTEN METAL POWDER LIST PRICES

Year	Average Annual Price Range, Dollars per Pound	
	Actual	1982 Dollars
1978	13.90 - 15.50	19.15 - 21.36
1979	13.90 - 15.50	17.62 - 19.65
1980	13.90 - 15.50	16.12 - 18.69
1981	13.90 - 15.50	14.73 - 16.43
1982	13.10 - 13.72	13.10 - 13.72
	Average price = \$16.14 - 17.97	

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

Because price varies with grain size and purity, it is difficult to determine a single tungsten price. For this reason, as well as the difficulty in identifying capacity utilization noted below, the 1982 value of products produced is used as a proxy for sales in this analysis.

The chapters on primary cobalt/nickel and secondary nickel contain a discussion of cobalt prices.

2. Capacity Utilization

Capacity utilization is computed from industry tungsten metal powder production and capacity data. These figures are presented in Table XVI-3 for the 1978-1982 period. The effects of the recession are readily observable in the thirty-point decline in utilization which occurred during 1982. However, recovery is expected as existing products wear out and as industrial activity accelerates, and industry experts predict strong growth through the end of the century.

Table XVI-4 presents production, capacity, and capacity utilization data for the domestic secondary cobalt industry. In general, capacity utilization rates have been high due to strong demand for cobalt products. The 1978-1982 period represents peak years, 1979 and 1980, and trough years, 1981 and 1982.

Capacity and production figures for plants in this study are not suitable indicators of capacity utilization. Primary and secondary metal production are often indistinguishable, and intermediate products are sometimes removed from further processing and sold. Therefore, the 1982 value of products produced is used as a proxy for sales in this analysis.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the secondary tungsten subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for three plants in the subcategory. However, closure analysis indicates that no plant will close. In addition, compliance costs for this subcategory are less than 1.3% of production costs under the most stringent treatment option.

TABLE XVI-3

TUNGSTEN METAL POWDER CAPACITY UTILIZATION

Year	Production (M. lbs.)	Capacity (M. lbs.)	Capacity Utilization (%)
1978	16.5	20.0	83
1979	18.4	20.0	92
1980	18.1	20.0	91
1981	19.8	21.0	94
1982	13.4	21.0	<u>64</u>
Average capacity utilization = 85%			

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

TABLE XVI-4

SECONDARY COBALT CAPACITY UTILIZATION

Year	Production (000 lbs.)	Capacity (000 lbs.)	Capacity Utilization (%)
1978	1,036	1,200	86
1979	1,170	1,200	98
1980	1,184	1,200	99
1981	972	1,200	81
1982	871	1,200	<u>73</u>
Average capacity utilization = 87%			

SOURCE: Personal communication, U.S. Department of the Interior, Bureau of Mines, January 1984.

CHAPTER XVII

SECONDARY URANIUM SUBCATEGORY

XVII. SECONDARY URANIUM SUBCATEGORY

A. RAW MATERIALS AND PRODUCTION PROCESSES

Uranium is derived from many ores. In the United States, carnotite ores of the Colorado Plateau and uraninite and coffinite ores of New Mexico and Wyoming are the most important reserves. Elsewhere in the world, pitchblende has been an important source of uranium.

The carnotite ores are first roasted to convert the vanadium content to water-soluble sodium vanadate. After grinding the ore, an acid or alkaline leaching process is used to recover uranium oxide. Sulfuric acid is the most commonly used leaching agent. Under the solvent extraction method, uranium is recovered from the sulfuric acid solution by the simple process of counter-current decantation. Other metallic substances, not dissolved in the sulfuric acid solution, go to waste tailings. Under the resin-in-pulp (ion exchange) method, the sulfuric acid solution is passed through beds of resin until the uranium is absorbed on the resin. The uranium is then removed from the resin by a nitric acid solution and is precipitated, filtered, and dried.

The recovered uranium oxide (U_3O_8) is converted to uranium hexafluoride (UF_6) before being further processed into nuclear reactor fuel. UF_6 contains enriched U_{235} and depleted U_{238} isotopes. The enriched U_{235} isotopes are separated from UF_6 by a process of gaseous diffusion. Some of the depleted UF_6 is reduced to UF_4 by reacting the UF_6 gas with hydrogen gas. UF_4 is then reduced to impure metal by heating it with magnesium fluoride powder. The impure depleted uranium, or "derby," is roasted and cleaned in water before being formed into rolls or other desired shapes. Depleted uranium alloys are also produced and marketed.

B. DESCRIPTION OF PLANTS

In the U.S., uranium enrichment is performed only at facilities which are owned by DOE and operated by private contractors. Under current DOE rules, customers with enrichment work done by DOE have the option of getting the depleted uranium back along with their enriched uranium, but few customers take the depleted uranium and ownership of most of it has reverted to DOE.

Three main companies process depleted uranium: TNS, Inc., Jonesboro, Tennessee; NLO, Inc., Cincinnati, Ohio; and Nuclear Metals, Inc., Concord, Massachusetts. The plants producing depleted uranium use uranium oxide (U_3O_8) and other intermediate products, such as uranium

hexafluoride (UF_6) and uranium tetrafluoride (UF_4). Magnesium, nitric acid, and anhydrous ammonia are other important raw materials used in the process. The TNS plant uses all the uranium it produces for captive consumption. The uranium is alloyed with titanium and other metals and sent to another plant for use in the manufacture of military ammunition. The Nuclear Metals plant also alloys titanium and molybdenum with uranium, apart from making pure uranium metal. NLO Inc. makes almost twice as much derby as pure metal.

Only one plant in this subcategory has been identified as a discharger of effluents. This plant is owned by the U.S. Department of Energy. Uranium at this plant is not produced for sale. For this reason the value of production cannot be calculated. However, because all production at this plant is consumed in government applications, this plant can be assumed to be completely insulated from market forces. Therefore, the limitations determined for this subcategory are considered economically achievable.

CHAPTER XVIII

PRIMARY ZIRCONIUM/HAFNIUM

SUBCATEGORY

XVIII. PRIMARY ZIRCONIUM/HAFNIUM
SUBCATEGORY

A. STRUCTURE OF THE INDUSTRY

1. Raw Materials and Production Processes

Zirconium and hafnium are contained in the mineral zircon in a ratio of about 50 to 1. Zircon is recovered as a coproduct or byproduct in the mining of the titanium minerals, ilmenite and rutile. Zircon itself is used extensively in foundry sands, refractories, ceramics, and abrasives. Only about 10% of the zircon produced is actually used to make zirconium and hafnium products.

Non-nuclear-grade zirconium metal contains hafnium as an impurity. In many applications the hafnium content, usually about 2%, does not detract from zirconium's usefulness. In fact prior to 1950, hafnium was not removed from zirconium. However, zirconium is most often used as a structural material in nuclear reactors where its very low neutron absorption cross section is of major importance. Because hafnium has one of the highest neutron absorption cross sections of any element, it must be removed from zirconium which is used for nuclear purposes. Hafnium is produced only as a byproduct of the production of nuclear-grade zirconium. Consequently, the supply of primary hafnium is limited by the demand for hafnium-free nuclear-grade zirconium.

Zirconium and hafnium are produced by chlorinating zircon sand and then separating zirconium and hafnium compounds through liquid-liquid extraction. Subsequent recovery of zirconium and hafnium proceeds separately but is roughly the same. Oxides are converted to chlorides and then reduced with magnesium to yield metal sponge. Zirconium sponge is crushed, compacted, and vacuum-melted in an inert atmosphere to produce zirconium ingot. Hafnium sponge is often converted to high-purity crystal bar, which is used in the production of nuclear control rods.

2. Description of Plants

The three major plants producing zirconium and hafnium in the U.S. are Teledyne Wah Chang Albany, in Albany, Oregon; Western Zirconium in Ogden, Utah; and Morton Thiokol, Inc., in Beverly, Massachusetts. Two of the plants recover nuclear-grade zirconium and hafnium from zircon sand. Both of these plants use this production captively in the manufacture of various end products. The other plant produces non-nuclear zirconium from zirconium dioxide. In all three instances,

revenues from zirconium and hafnium production represent less than 65% of total plant shipments. Of the three plants, one is a direct discharger, one is an indirect discharger, and one is a zero discharger. Because certain zirconium and titanium production facilities are similar and can be used interchangeably, two of the plants also produce titanium and discharge titanium effluents.

Two types of plants, Level A and Level B, have been identified in this subcategory (see Chapter II). The indirect discharger has been identified as a Level A plant. The Agency has considered the possibility that the Level A plant may at some point engage in Level B processes and therefore be subject to Level B limitations. The impacts of these limitations have been estimated and are discussed in Chapter XXV -- Limitations of the Analysis.

3. U.S. Production, Consumption, and Trade

Table XVIII-1 shows imports of zirconium metal for the years 1978-1982. During the past four years, the domestic nuclear reactor program has experienced significant setbacks, and the decline in this major market segment has affected both imports and domestic production of zirconium. Imports fell 53% between 1978 and 1982. Additionally, the fast-paced construction of nuclear reactors overseas is of only limited consequence to U.S. zirconium producers. Some countries, particularly Japan, which has 16 new reactors planned, have specified that certain reactor parts, notably those containing zirconium, must be manufactured domestically. U.S. zirconium metal production is currently estimated to be about 4,000 tons per year.

Table XVIII-2 presents hafnium crystal bar production for the same period. Because hafnium control rods have been used almost exclusively in military reactors, production has been largely insulated from market forces and hence is quite stable. Imports of hafnium are negligible and there have been no exports. There are no stockpile objectives for either zirconium or hafnium.

4. End Uses and Substitutes

During 1982, about 60% of domestic zirconium consumption was in the form of hafnium-free nuclear-grade alloys. The remainder was consumed in various non-nuclear industrial applications. For instance, zirconium is commonly added to magnesium, aluminum, and steel. Additions of less than 1% increase the strength and corrosion resistance of these metals.

TABLE XVIII-1

U.S. ZIRCONIUM METAL IMPORTS

(short tons)

	1978	1979	1980	1981	1982a
Imports	990	916	721	513	420

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

aEstimated.

TABLE XVIII-2

U.S. HAFNIUM CRYSTAL BAR PRODUCTION
(short tons)

	1978	1979	1980	1981	1982
Production ^a	40	45	45	50	50

SOURCE: Mineral Commodity Summaries, U.S. Department of the Interior,
Bureau of Mines, 1983.

^aEstimated.

Stainless steel is often substituted for zirconium in nuclear reactor structures. Substitutes also exist for industrial applications. Stainless steel, titanium, and tantalum are often suitable where corrosion resistance is required.

Virtually all hafnium metal is consumed in nuclear applications. Hafnium's high neutron absorption cross section commends its use to the U.S. Navy, its largest consumer, in the construction of smaller reactors, such as those on ships and submarines. Small amounts of hafnium are also used in refractory alloys and in cutting tool alloys where numerous substitutes exist.

B. MARKET TRENDS AND DEVELOPMENTS

1. Prices

Unlike most metals studied, zirconium and hafnium have no quoted prices and are not traded in any commodity markets. Prices are negotiated between the supplier and the customer and depend on the grade and quantity produced. Nevertheless, prices in reported transactions are compiled. The reported price ranges for zirconium and hafnium sponge over the 1978-1982 period are found in Tables XVIII-3 and XVIII-4 respectively. These ranges reflect prices paid only in those transactions reported and do not make any distinction between the various grades bought and sold. Therefore, trends in price cannot be obtained through analysis of this data.

2. Capacity Utilization

The value of products produced in 1982 is known for each of the two plants under analysis. Because demand is so closely tied to the proliferation of nuclear power plants, the low utilization rates of 1982 are expected to persist for both zirconium and hafnium into the immediate future. Therefore, the 1982 production values will be used in the analysis.

C. IMPACT ASSESSMENT

The proposed regulation is not expected to have a significant impact on plants in the zirconium/hafnium subcategory. Results of the screening test show that annual compliance costs exceed 1% of revenues for the two plants identified as dischargers of effluents. However, closure analysis indicates that neither plant will close. In addition, compliance costs for this subcategory are less than 2.5% of production costs under the most stringent treatment option.

TABLE XVIII-3

ZIRCONIUM SPONGE PRICES

Year	Average Annual Price Range, Dollars per Pound	
	Actual	1982 Dollars
1978	9.00 - 15.00	12.40 - 20.70
1979	9.00 - 12.00	11.40 - 15.20
1980	10.00 - 14.00	11.60 - 16.20
1981	12.00 - 17.00	12.70 - 18.00
1982	12.00 - 17.00	12.00 - 17.00
	Average price = \$12.00 - 17.40	

SOURCE: Minerals Yearbook, U.S. Department of the Interior, Bureau of Mines, 1979-1982.

TABLE XVIII-4

HAFNIUM SPONGE PRICES

Year	Average Annual Price Range, Dollars per Pound	
	Actual	1982 Dollars
1978	55.00 - 110.00	75.80 - 151.60
1979	60.00 - 90.00	76.10 - 114.10
1980	55.00 - 110.00	63.80 - 127.60
1981	70.00 - 135.00	74.20 - 143.10
1982	80.00 - 150.00	80.00 - 150.00
	Average price = \$74.00 - 137.30	

SOURCE: Minerals Yearbook, U.S. Department of the Interior, Bureau of Mines, 1979-1982.

CHAPTER XIX

PRIMARY BORON SUBCATEGORY

XIX. PRIMARY BORON SUBCATEGORY

A. RAW MATERIALS AND PRODUCTION PROCESSES

Boron and its compounds are obtained chiefly from two ores -- sodium borate (tincal) and calcium borate (colemanite). In the United States, the sodium borate ore is crushed and floated to raise the anhydrous borax (B_2O_3) content to approximately 40%. Further refining, principally by calcining, yields various grades of borax hydrates. Boric acid is obtained by treating the hydrates with sulfuric acid or by treating the calcium borate ore directly with sulfuric acid. The B_2O_3 and anhydrous boric acid ($Na_2O \cdot 2B_2O_3$) are obtained by a process of combined acidification and fusion. Elemental boron, which is a dark brown powder in the amorphous form, is derived from anhydrous boric acid by reducing it with magnesium. Magnesium reacts with B_2O_3 to become magnesium oxide. Elemental boron is recovered by dissolving the magnesium oxide in hydrochloric acid and filtering and washing the residue, which is pure boron.

Lake brines processed for boron also provide other compounds, such as sodium carbonate, sodium sulfate, potassium sulfate, and potassium chloride. From the upper structures of brines, borax and other elements are obtained by the evaporative or "trona" process. Soda ash and borax from the lower structures are recovered by the carbonation process, wherein carbon dioxide from calcining limestone is used to precipitate soda ash from the mixed brines.

Secondary recovery and re-use of boron compounds is conducted on a very small scale, as almost all of the compounds go into dissipative uses. Boron is recovered from boron bromides or fluorides by vaporizing these chemicals and collecting the vapors on a hot surface.

B. DESCRIPTION OF PLANTS

U.S. production of boron minerals, primarily sodium borate (tincal), is centered in southern California. Kerr-McGee Chemical Corporation has two facilities which extract sodium borates, boric acid, borax powder, and other compounds from the subterranean brines of Searles Lake. The Mine Safety Appliances Company produces boron from decomposed diborane gas (B_2H_6). Its main line of business, however, is the manufacture of safety equipment, gas masks, and protective clothing. These two plants are zero dischargers. Therefore, further analysis will not be performed for existing sources.

Economic impacts for new sources in this subcategory are discussed in Chapter XXIII -- New Source Impacts.

CHAPTER XX

PRIMARY CESIUM/RUBIDIUM SUBCATEGORY

XX. PRIMARY CESIUM/RUBIDIUM SUBCATEGORY

A. RAW MATERIALS AND PRODUCTION PROCESSES

Cesium is derived principally from pollucite (20%-40% cesium oxide) ore, which itself is recovered as a coproduct in mining pegmatites from lithium minerals and beryl. Rubidium is derived principally from lepidolite ore, which is recovered from the same kinds of lithium-bearing pegmatite deposits as is cesium. Rubidium has also been recovered as a byproduct of the processing of pollucite for its cesium content. Strontium is recovered from celestite (SrSO_4) and strontionite (SrCO_3).

Cesium and rubidium are produced by similar processes. The respective ore concentrates are digested in sulfuric acid and the impurities are removed by filtration. The cesium and rubidium chemicals are dissolved in hydrochloric acid to form chlorides. The metal is then recovered by a thermochemical reduction process.

Strontium is recovered from celestite or strontionite by first converting the ore to strontium oxide and then reducing the oxide with metallic aluminum. The metal is also produced through the electrolysis of fused strontium chloride. Strontium carbonate is one of the many strontium chemicals that are in demand.

Cesium and rubidium are produced in the form of metal, compounds, and oxide. Cesium metal is sold in two purities: standard (99.5% minimum cesium content) and high-purity (99.9% minimum cesium content). Rubidium metal is also available in two purities: standard (99.5% minimum rubidium content) and high-purity (99.8% minimum rubidium content). Compounds are also available in two grades: technical grade, 99% minimum; and high purity, 99.9% minimum (99.8% minimum for rubidium). Available compounds are acetate, bromide, carbonate, chloride, chromate, fluoride, hydroxide, iodide, nitrate, and sulfate.

B. DESCRIPTION OF PLANTS

The Agency has identified the KBI Division of Cabot Corporation as the only producer in this subcategory. Its plant at Revere, Pennsylvania produces cesium and rubidium mainly from imported ores. This plant is a zero discharger. Because of limited demand, manufacturing capacity is very flexible and normally does not greatly exceed demand. The Cabot plant also produces germanium for which it is a zero discharger. Because this plant does not discharge effluents, further analysis will not be performed for existing sources.

Economic impacts for new sources in this subcategory are discussed in Chapter XXIII -- New Source Impacts.

CHAPTER XXI

SECONDARY MERCURY SUBCATEGORY

XXI. SECONDARY MERCURY SUBCATEGORY

A. RAW MATERIALS AND PRODUCTION PROCESSES

Secondary sources are an important component of mercury supply. During the past several years, dental amalgams have been the most common single source of mercury. Industrial wastes, especially from chlor-alkali plants and mercury batteries, have also become important sources of secondary recovery. Virtually all metal can be reclaimed when the plant or equipment is dismantled or scrapped. Mercury is decomposed from scrap by distillation or retorting. Subsequent washing in dilute nitric acid and distilled water yields 99.9% pure mercury.

B. DESCRIPTION OF PLANTS

Four plants have been identified in the Secondary Mercury subcategory. Mercury Refining Co. in Albany, New York and Bethlehem Apparatus Co., Hellertown, Pennsylvania are both zero dischargers and are not analyzed further. D.F. Goldsmith Chemical and Metal Corp. in Evanston, Illinois and Kahl Scientific Instrument Corp. in El Cajon, California both use processes which produce no wastewater. Consequently, further analysis is not performed for existing sources. Economic impacts for new sources in this subcategory are discussed in Chapter XXIII -- New Source Impacts.

CHAPTER XXII

ECONOMIC IMPACTS

XXII. ECONOMIC IMPACTS

The economic impact of the proposed effluent limitations has been performed by first screening plants for potential impact and then analyzing the impacted plants to identify possible closures. The screening analysis compares a plant's total annual compliance costs to its annual revenues. If the ratio of compliance costs to revenues exceeds 1%, the plant is identified as a high impact plant. The high impact plants are evaluated with the help of the NPV and liquidity tests. Plants failing either of these tests are potential closure candidates.

A. PLANT-LEVEL ECONOMIC IMPACTS

The analysis is conducted in two steps. First, a screening analysis is conducted to identify plants that will not be seriously affected by the regulations. Second, the NPV and liquidity tests are performed to determine whether plants that fail the screen will close. Results of the screen and closure tests are discussed below.

1. Results of Screening Analysis

Total annual costs as a percentage of annual revenues is used as the screening criterion. The threshold value chosen for the screen is 1%. In other words, if the compliance costs for a plant are less than 1% of the revenues, it is not considered to be highly affected.

Tables XXII-1A and XXII-1B present the results of the screening analysis for direct and indirect dischargers respectively. Of the 71 plants incurring costs, 12 plants fail the screen at Option A, 5 fail at Option B, and 15 plants fail at Option C. No plants fail at Option E. No more than one plant fails the screen at any option for the following subcategories: Primary Molybdenum/Rhenium, Secondary Molybdenum/Vanadium, Primary Nickel/Cobalt, Secondary Nickel, Primary Beryllium, Primary and Secondary Germanium/Gallium, Secondary Indium, Primary and Secondary Titanium, Primary Precious Metals/Mercury, Secondary Precious Metals, Primary Rare-Earth Metals, Secondary Tantalum, Bauxite Refining, and Primary Antimony. Total annual compliance costs for three tungsten/cobalt plants, two zirconium/hafnium plants, and four tin plants exceed 1% of revenues at Option C. Plants failing the screen are analyzed further using the NPV and liquidity tests.

TABLE XXII-1A

RESULTS OF CLOSURE ANALYSIS -- DIRECT DISCHARGERS

Subcategory	Number of Plants Incurring Costs	Total Investment Cost (1982 Dollars)	Total Annual Cost (1982 Dollars)	Number of Plants Failing Screen	Potential Closures	Employment Loss
Primary Antimony ^a						
Option A	1	36,634	13,698	0	0	0
Option C	1	44,137	16,767	0	0	0
Bauxite Refining ^b						
Option E	4	8,290,029	2,103,082	0	0	0
Primary Beryllium ^c						
Option B	1	W	W	0	0	0
Option C	1	W	W	0	0	0
Primary and Secondary Germanium/Gallium ^a						
Option A	0					
Option C	0					
Secondary Iodine ^a						
Option A	0					
Option C	0					
Primary Molybdenum/Rhenium						
Option A	4	208,551	338,499	0	0	0
Option B	4	208,551	338,499	0	0	0
Option C	4	347,313	414,072	0	0	0
Secondary Molybdenum/ Vanadium ^a						
Option A	1	W	W	1	0	0
Option C	1	W	W	1	0	0
Primary Nickel/Cobalt ^a						
Option A	1	W	W	0	0	0
Option C	1	W	W	0	0	0
Secondary Nickel ^a						
Option A	0					
Option C	0					
Primary Precious Metals/ Mercury ^a						
Option A	1	27,500	8,610	0	0	0
Option C	1	29,975	9,755	0	0	0
Secondary Precious Metals						
Option A	3	299,535	240,155	0	0	0
Option B	3	299,535	242,505	0	0	0
Option C	3	306,846	251,434	0	0	0
Primary Rare-Earth Metals						
Option A	1	W	W	0	0	0
Option B	1	W	W	0	0	0
Option C	1	W	W	0	0	0
Option E	1	W	W	0	0	0
Secondary Tantalum ^a						
Option A	3	7,270	44,708	0	0	0
Option C	3	15,437	48,962	0	0	0
Primary and Secondary Tin ^a						
Option A	3	829,757	348,124	2	2	29
Option C	3	938,773	381,108	2	2	29
Primary and Secondary Titanium						
Option A	4	1,224,289	519,237	0	0	0
Option B	4	1,225,075	519,898	0	0	0
Option C	4	1,334,834	558,753	0	0	0
Secondary Tungsten/Cobalt						
Option A	4	93,912	272,620	2	0	0
Option B	4	103,165	283,711	2	0	0
Option C	4	135,148	295,353	3	0	0
Secondary Uranium ^a						
Option A	1	28,600	49,301	NA	NA	NA
Option C	1	54,313	58,379	NA	NA	NA
Primary Zirconium/Hafnium						
Option A	1	W	W	1	0	0
Option B	1	W	W	1	0	0
Option C	1	W	W	1	0	0

^aTreatment Level B is not a viable option.

^bThe Agency is presently proposing only technical amendments to existing Bauxite Regulations; however, it is considering toxic limitations on the net precipitation discharges from Bauxite redmud impoundments. The Bauxite numbers in this table and elsewhere in this document refer to the toxic limitations under consideration by the Agency.

^cTreatment Level A is already in place.

W -- Withheld to avoid disclosing company proprietary data.

NA -- Not applicable.

TABLE XXII-1B

RESULTS OF CLOSURE ANALYSIS -- INDIRECT DISCHARGERS

Subcategory	Number of Plants Incurring Costs	Total Investment Cost (1982 Dollars)	Total Annual Cost (1982 Dollars)	Number of Plants Failing Screen	Potential Closures	Employment Loss
Primary Antimony ^a						
Option A	0					
Option C	0					
Bauxite Refining						
Option E	0					
Primary Beryllium ^b						
Option B	0					
Option C	0					
Primary and Secondary Germanium/Gallium ^a						
Option A	1	W	W	0	0	0
Option C	1	W	W	1	0	0
Secondary Iodine ^a						
Option A	1	W	W	1	0	0
Option C	1	W	W	1	0	0
Primary Molybdenum/Rhenium						
Option A	0					
Option B	0					
Option C	0					
Secondary Molybdenum/ Vanadium ^a						
Option A	0					
Option C	0					
Primary Nickel/Cobalt ^a						
Option A	0					
Option C	0					
Secondary Nickel ^a						
Option A	1	W	W	1	0	0
Option C	1	W	W	1	0	0
Primary Precious Metals/ Mercury ^a						
Option A	0					
Option C	0					
Secondary Precious Metals						
Option A	29	1,731,246	856,333	1	1	4
Option B	29	1,736,619	866,895	1	1	4
Option C	29	1,844,518	916,476	1	1	4
Primary Rare-Earth Metals						
Option A	1	W	W	0	0	0
Option B	1	W	W	0	0	0
Option C	1	W	W	0	0	0
Option E	1	W	W	0	0	0
Secondary Tantalum ^a						
Option A	0					
Option C	0					
Primary and Secondary Tin ^a						
Option A	2	W	W	2	2	14
Option C	2	W	W	2	2	14
Primary and Secondary Titanium						
Option A	2	W	W	1	0	0
Option B	2	W	W	1	0	0
Option C	2	W	W	1	0	0
Secondary Tungsten/Cobalt						
Option A	0					
Option B	0					
Option C	0					
Secondary Uranium						
Option A	0					
Option C	0					
Primary Zirconium/Hafnium ^c						
Option C	1	W	W	1	0	0

^aTreatment Level B is not a viable option.^bTreatment Level A is already in place.^cTreatment Levels A and B are already in place.

W - Withheld to avoid disclosing company proprietary data.

2. Results of the Closure Analysis

The NPV test examines a plant's long-term viability, while the liquidity test measures a plant's ability to generate sufficient cash flow to cover compliance costs in the short run. A plant is projected as a potential closure if it fails either of the two tests.

Results of the closure analysis are presented in Tables XXII-1A and XXII-1B for direct and indirect dischargers respectively. Potential plant closures have been identified in only two subcategories. One secondary precious metals plant fails the NPV test at all three treatment options. Of the four tin plants, three fail both tests at all three options, while one fails only the NPV test.

One plant has been identified as a potential closure in the Secondary Precious Metals subcategory. However, analysis shows that the Secondary Precious Metals subcategory as a whole is not significantly affected by the pollution control costs. This plant represents about 0.02% of the total capacity of plants incurring costs in this subcategory. Built about 25 years ago, this plant added a new nonferrous metal process line in 1982.

Of the four tin plants that have been identified as potential closures, three have been classified as plant closures and one has been classified as a line closure. Tin operations at the plant identified as a line closure accounted for only .3% of total plant shipments in 1982. The four tin facilities represent about 12% of the total subcategory capacity. One plant began nonferrous metals manufacturing in the early 1950s. The other three plants are relatively new, having commenced operations about 20 years ago. All four plants produce tin primarily from tin scrap, tin sludge, and tin slurry. Tin metal as ingot and powder, tin dross, and tin mud are the chief products of these plants. Tin metal commands a higher market price than the other tin products because of its high purity.

The identification of plants as potential closures in this step is interpreted as an indication of the extent of plant impact rather than as a prediction of certain closure. The decision by a company to close a plant also involves other considerations, such as non-competitive markets for products, degree of integration of operation, use of output of plants as intermediate products (captive markets), and existence of specialty markets.

B. OTHER IMPACTS

The general industry-wide impacts of the effluent guidelines on the nonferrous metals manufacturing subcategories covered in this rulemaking have been determined using the procedure outlined in Chapter I -- Methodology. Each of the impacts that have been evaluated for the different subcategories is described below.

1. Average Change in Return on Investment

The return on investment (ROI) is an accurate measure of a firm's profitability. Therefore, the post-compliance ROI for each plant was calculated and compared to the pre-compliance ROI to find out whether the proposed regulations would significantly affect the profitability of plants. The results of this analysis are presented in Tables XXII-2A and XXII-2B.

The decline in ROI is expected to be minimal (less than 3%) in the Primary Molybdenum/Rhenium, Primary Nickel/Cobalt, Primary and Secondary Titanium, Primary Beryllium, Primary Precious Metals/Mercury, and Secondary Precious Metals subcategories. The decrease in profitability in the Primary Rare-Earth Metals, Primary and Secondary Germanium/Gallium, Secondary Indium, Secondary Tantalum, Secondary Tungsten/Cobalt, Bauxite Refining, and Primary Antimony subcategories is expected to be less than 10% even under the most costly option. Firms belonging to the Primary and Secondary Tin, Primary Zirconium/Hafnium, Secondary Molybdenum/Vanadium, and Secondary Nickel subcategories will experience greater decreases in profits under the most costly option, due to the combined effect of higher costs and lower margins.

2. Average Increase in Production Cost

A change in production cost directly affects the profitability of a firm. This measure summarizes the financial impact of the regulatory alternatives on the firms in the nonferrous metals manufacturing industry. The analysis presented in Tables XXII-2A and XXII-2B does not show a marked increase in production cost in any of the subcategories. In fact, there is only a small increase (less than 1%) for most of the firms. Primary Zirconium/Hafnium, Primary and Secondary Tin, and Secondary Nickel are the only subcategories incurring costs greater than 2%. The maximum increase occurs in the Secondary Nickel subcategory (about 3%).

The discharging plant in the Secondary Nickel subcategory produces high-purity alloys from both primary and secondary sources. The proposed effluent guidelines regulate only waste recovery of

TABLE XXII-2A

OTHER IMPACTS -- DIRECT DISCHARGERS

Subcategory	Number of Plants Incurring Costs	Average % Change In Return on Investment	Average % Increase in Production Cost	Average % Price Change	Average Investment Cost as a % of Capital Expenditure
Primary Antimony^a					
Option A	1	-4.99	0.90	0.72	13.53
Option C	1	-6.06	1.10	0.88	16.30
Bauxite Refining^b					
Option E	4	-5.32	0.31	0.29	9.48
Primary Beryllium^c					
Option B	1	-0.07	0.01	0.01	0.24
Option C	1	-0.11	0.02	0.01	0.34
Primary and Secondary Germanium/Gallium^a					
Option A	0				
Option C	0				
Secondary Iodine^a					
Option A	0				
Option C	0				
Primary Molybdenum/Rhenium					
Option A	4	-0.36	0.08	0.06	0.27
Option B	4	-0.36	0.08	0.06	0.27
Option C	4	-0.44	0.09	0.07	0.44
Secondary Molybdenum/ Vanadium^a					
Option A	1	-14.91	1.36	1.24	3.61
Option C	1	-16.18	1.44	1.32	8.19
Primary Nickel/Cobalt^a					
Option A	1	-0.04	0.01	0.01	0.09
Option C	1	-0.05	0.01	0.01	0.09
Secondary Nickel^a					
Option A	0				
Option C	0				
Primary Precious Metals/ Mercury^a					
Option A	1	-0.87	0.20	0.14	4.43
Option C	1	-0.97	0.23	0.16	4.82
Secondary Precious Metals					
Option A	3	-0.28	0.02	0.05	2.63
Option B	3	-0.28	0.02	0.05	2.63
Option C	3	-0.29	0.02	0.06	2.69
Primary Rare-Earth Metals					
Option A	1	-3.68	0.27	0.28	1.70
Option B	1	-3.68	0.27	0.30	1.70
Option C	1	-4.19	0.32	0.34	1.87
Option E	1	-6.40	0.46	0.49	3.45
Secondary Tantalum^a					
Option A	3	-6.03	0.17	0.16	0.81
Option C	3	-6.64	0.18	0.18	1.73
Primary and Secondary Tin^a					
Option A	3	-22.75	0.60	0.55	42.16
Option C	3	-24.91	0.65	0.71	47.70
Primary and Secondary Titanium					
Option A	4	-0.94	0.13	0.12	2.06
Option B	4	-0.95	0.13	0.12	2.06
Option C	4	-1.02	0.14	0.13	2.25
Secondary Tungsten/Cobalt					
Option A	4	-7.65	1.22	1.05	3.97
Option B	4	-7.98	1.27	1.09	4.37
Option C	4	-8.41	1.32	1.13	5.72
Secondary Uranium					
Option A	1	NA	NA	NA	NA
Option C	1	NA	NA	NA	NA
Primary Zirconium/Hafnium					
Option A	1	-16.17	2.41	2.05	21.92
Option B	1	-16.17	2.41	2.05	21.92
Option C	1	-16.66	2.48	2.12	23.54

^aTreatment Level B is not a viable option.^bThe Agency is presently proposing only technical amendments to existing Bauxite Regulations; however, it is considering toxic limitations on the net precipitation discharges from Bauxite redmud impoundments. The Bauxite numbers in this table and elsewhere in this document refer to the toxic limitations under consideration by the Agency.^cTreatment Level A is already in place.

NA -- Not applicable.

TABLE XXII-2B

OTHER IMPACTS -- INDIRECT DISCHARGERS

Subcategory	Number of Plants Incurring Costs	Average % Change In Return on Investment	Average % Increase in Production Cost	Average % Price Change	Average Investment Cost as a % of Capital Expenditure
Primary Antimony ^a					
Option A	0				
Option C	0				
Bauxite Refining					
Option E	0				
Primary Beryllium ^b					
Option B	0				
Option C	0				
Primary and Secondary Germanium/Gallium ^a					
Option A	1	-8.31	1.12	0.96	18.63
Option C	1	-9.18	1.23	1.05	21.44
Secondary Indium ^a					
Option A	1	-8.36	1.23	1.05	11.72
Option C	1	-9.12	1.33	1.14	13.86
Primary Molybdenum/Rhenium					
Option A	0				
Option B	0				
Option C	0				
Secondary Molybdenum/ Vanadium ^a					
Option A	0				
Option C	0				
Primary Nickel/Cobalt ^a					
Option A	0				
Option C	0				
Secondary Nickel ^a					
Option A	1	-33.24	2.27	2.08	147.09
Option C	1	-39.63	2.80	2.56	175.43
Primary Precious Metals/ Mercury ^a					
Option A	0				
Option C	0				
Secondary Precious Metals					
Option A	29	-1.44	0.11	0.05	19.33
Option B	29	-1.45	0.11	0.05	19.39
Option C	29	-1.53	0.11	0.06	20.60
Primary Rare-Earth Metals					
Option A	1	-4.91	0.35	0.28	2.57
Option B	1	-6.22	0.41	0.30	4.01
Option C	1	-6.74	0.45	0.34	4.22
Option E	1	-9.92	0.66	0.49	6.63
Secondary Tantalum ^a					
Option A	0				
Option C	0				
Primary and Secondary Tin ^a					
Option A	2	-74.40	1.99	0.65	314.28
Option C	2	-79.20	2.14	0.71	322.07
Primary and Secondary Titanium					
Option A	2	-1.86	0.40	0.12	2.79
Option B	2	-1.96	0.41	0.12	3.21
Option C	2	-2.51	0.51	0.13	4.75
Secondary Tungsten/Cobalt					
Option A	0				
Option B	0				
Option C	0				
Secondary Uranium ^a					
Option A	0				
Option C	0				
Primary Zirconium/Hafnium ^c					
Option C	1	-14.17	2.10	2.12	19.46

^aTreatment Level B is not a viable option.^bTreatment Level A is already in place.^cTreatment Levels A and B are already in place.

nickel. The value of nickel in the slag is only a small percentage of the total value of shipments from this plant. The large increase in the cost of producing nickel from waste does not, therefore, represent a significant increase in the total cost of production at this facility.

3. Price Increase

The immediate response to an increase in the cost of production is generally an attempt to increase the price of the product. Often, producers try to pass all costs on to the consumers. A full pass-through of costs may not be possible at all times and is especially difficult in a competitive market. Although no cost pass-through was assumed for the closure analysis, it is useful to examine the increases in price that would be necessary if a plant elected to do so. The ratio of annual compliance cost to revenues gives a reasonable estimate of the increase in price required to cover compliance costs. The results in Tables XXII-2A and XXII-2B are similar to the results for change in cost of production.

The minimal changes in price may appear markedly different from those for the change in ROI. This apparent discrepancy can be explained by examining industry profit margins. For example, the Secondary Indium subcategory is characterized by low profit margins. Looking at Table XXII-2B, it can be seen that even though a price increase of less than 2% would be sufficient to pass through the compliance costs, plants in the subcategory are expected to experience a change in ROI of nearly 10%. It should be noted that no plant closures are identified for the Secondary Indium subcategory, indicating low overall impact.

4. Average Investment Cost as a Percentage of Capital Expenditures

The analysis compared the required pollution control investment cost to the pre-compliance average annual capital expenditures of the firms. The results show that the Primary and Secondary Tin and Secondary Nickel subcategories are expected to incur relatively high control costs in relation to their existing annual capital expenditures. This effect could be due to high control costs as well as to low annual capital expenditures. Low annual capital expenditures can be attributed to the fact that these industries are not experiencing rapid growth. The new control expenditures are expected to have a minimal impact on most subcategories, as is shown in Tables XXII-2A and XXII-2B.

5. Employment Impacts

The employment impacts of the regulatory costs have been examined in the context of plant closures. Potential plant and line closures have been identified in the Primary and Secondary Tin and Secondary Precious Metals subcategories. The closure of these plants could cause an employment loss of about 47 workers. The remaining subcategories are not impacted sufficiently to cause plant closures. Given the low price and production effects in these subcategories, employment effects are expected to be minimal. Minor production decreases could occur as a result of shifts in capacity utilization rather than loss of capacity.

6. Foreign Trade Impacts

The foreign trade impacts are analyzed with respect to the effect of regulatory costs on the balance of trade. The closure of high-impact plants could result in a loss of capacity of over 650 short tons. However, the impact could be minimized if other plants increase their production levels. To the extent that the existing or new plants make up for the lost capacity, the balance of trade will not be adversely impacted.

CHAPTER XXIII

NEW SOURCE IMPACTS

XXIII. NEW SOURCE IMPACTS

The basis for new source performance standards (NSPS) and pretreatment standards for new sources (PSNS), as established under Section 306 of the Clean Water Act, is the best available demonstrated control technology. Builders of new facilities have the opportunity to install the best available production processes and wastewater treatment technologies, without incurring the added costs and restrictions encountered in retrofitting an existing facility. Therefore, Congress directed EPA to require that the best demonstrated process changes, in-plant controls, and end-of-pipe treatment technologies be installed in new facilities. For regulatory purposes new sources include greenfield plants and major modifications to existing plants.

The potential economic impact of concern to EPA in evaluating new source regulations is the extent to which these regulations represent a barrier to the construction of new facilities or exert pressures on existing plants to modernize, and thereby reduce the growth potential of the industry.

In evaluating the potential economic impact of the NSPS/PSNS regulations on new sources, it is necessary to consider the costs of the regulations relative to the costs incurred by existing sources under the BAT/PSES regulations. For most subcategories with existing sources, new source technologies are the same as those for existing sources and, therefore, no incremental cost will be incurred by new source plants. For this reason, new sources will not be operating at a cost disadvantage relative to existing sources due to this regulation.

For the Secondary Indium subcategory, the selected treatment option for existing sources consists of lime and settle technology only. New indium plants will be required to add filtration to the lime and settle technology to meet effluent limitations. Table XXIII-1 shows a comparison between the economic impacts associated with selected options for existing sources versus new sources. The table shows that neither the existing nor the new source would be expected to incur significant impacts. The incremental impact for new sources over existing sources is also very small. These additional costs should not pose a barrier to entry for new indium plants.

There are three subcategories for which there are no existing dischargers: Primary Cesium/Rubidium, Secondary Mercury, and Primary Boron. Economic impacts have been calculated based on model plants in these subcategories. The model plants represent average production of existing nondischarging plants. The production levels used for each subcategory are withheld to avoid disclosing company proprietary data.

TABLE XXIII-1

COMPARISON OF ECONOMIC IMPACTS FOR
EXISTING AND NEW INDIUM PLANTS

	Existing Sources	New Sources
Total Investment Cost (1982 \$)	W	20,487
Total Annual Cost (1982 \$)	W	18,562
Number of Plants Failing Screening	1	1
Number of Plants Failing NPV Test	0	0
% Change in Return on Investment	-8.36	-9.12
% Increase in Production Cost	1.23	1.33
% Price Change	1.05	1.14
Investment Cost as a % of Capital Expenditures	11.72	13.86

W -- Withheld to avoid disclosing company proprietary data.

The economic impact analysis used for existing sources is employed to assess the impact for the new source subcategories; namely a screening analysis is performed and a NPV and liquidity test are conducted for those plants projected to incur annual compliance costs in excess of 1% of plant revenues.

The economic impacts for each new source subcategory are shown in Tables XXIII-2, XXIII-3, and XXIII-4. The results show that the estimated annual compliance costs do not exceed 1% of plant revenues in the Primary Cesium/Rubidium or Secondary Mercury subcategories. Other impacts in these subcategories are also small. The new source limitations for the Primary Cesium/Rubidium and Secondary Mercury subcategories are based on lime and settle plus filtration. In both instances, contract hauling is assumed to be the most economical method of attaining the required limitations. For this reason, contract hauling costs are used in the economic analysis.

Annual costs as a percent of plant revenues exceeds 1% for the Primary Boron subcategory. However, the results of the NPV test indicate that after-compliance income to liquidation value for the model plant exceeds the required cost of capital (\bar{r}). New source limitations for the Primary Boron subcategory are based on lime and settle technology.

The economic impacts calculated for these new source categories are not significant and, therefore, are not expected to pose a barrier to entry.

TABLE XXIII-2

SUMMARY OF NEW SOURCE IMPACTS

PRIMARY CESIUM/RUBIDIUM

Annual Production of Model Plant (lbs./yr.)	
Cesium	W
Rubidium	W
Total Investment Costs (1982 \$)	W
Total Annual Costs (1982 \$)	W
Screening Analysis (%)	0.11
% Change in Return on Investment	-0.79
% Increase in Production Cost	0.13
% Price Change	0.11
Investment Cost as a % of Capital Expenditures	0

W -- Withheld to avoid disclosing company proprietary data.

TABLE XXIII-3

SUMMARY OF NEW SOURCE IMPACTS

SECONDARY MERCURY

Annual Production of Model Plant (lbs./yr.)	W
Total Investment Costs (1982 \$)	0
Total Annual Costs (1982 \$)	396
Screening Analysis (%)	0.07
% Change in Return on Investment	-2.73
% Increase in Production Cost	0.08
% Price Change	0.07
Investment Cost as a % of Capital Expenditures	0

W -- Withheld to avoid disclosing company proprietary data.

TABLE XXIII-4

SUMMARY OF NEW SOURCE IMPACTS

PRIMARY BORON

Annual Production of Model Plant (lbs./yr.)	W
Total Investment Costs (1982 \$)	W
Total Annual Costs (1982 \$)	W
NPV Test:	
Income to Liquidation Value (U/L)	31.33
Real Cost of Capital (F)	14.66
% Change in Return on Investment	-9.98
% Increase in Production Cost	1.17
% Price Change	1.01
Investment Cost as a % of Capital Expenditures	35.17

W -- Withheld to avoid disclosing company proprietary data.

CHAPTER XXIV

SMALL BUSINESS ANALYSIS

XXIV. SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354), which amends the Administrative Procedures Act, requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires an initial screening analysis to be performed to determine whether a substantial number of small entities will be significantly affected. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered. This chapter addresses these objectives by identifying and evaluating the economic impacts of the effluent control regulations on small nonferrous metals manufacturers. As described in Chapter I, the small business analysis was developed as an integral part of the general economic impact analysis and was based on an examination of plant capacity levels and compliance costs incurred as a result of the regulations. Based on this analysis, EPA has determined that a substantial number of small entities will not be significantly affected.

For purposes of this small business analysis, the following alternative approaches were considered for defining small nonferrous metal smelting and refining operations:

- the Small Business Administration (SBA) definition;
- annual plant capacity; and
- annual plant production.

In the nonferrous metals smelting and refining industry, the SBA defines as small those firms whose employment is fewer than 2,500 for primary producers and fewer than 500 for secondary producers. This definition is, however, inappropriate because this analysis is concerned only with plants operating as distinct units rather than with firms composed of several plants. Many of the plants are, in fact, owned by firms that produce metals not covered by this regulation. In order to avoid confusion and to maintain consistency, annual plant capacity was used as an indicator of size. Because industry segments are assumed to operate at uniform capacity utilization levels during the impact period, annual plant production yields the same classification as annual plant capacity.

In order to designate large and small plants for this small business analysis, all plants in a subcategory were first ranked by annual capacity. This ranking revealed a clear distribution between large and small plants. The following definitions of small plants are derived from this review of annual plant capacities.

Industry Subcategory	Annual Plant Capacity
Primary and Secondary Tin	1,000,000 pounds
Primary and Secondary Titanium	1,000,000 pounds
Primary Zirconium/Hafnium	1,000,000 pounds
Secondary Precious Metals	1,500 pounds
Secondary Tungsten/Cobalt	500,000 pounds

Small plants subject to this regulation were not identified in the other subcategories. The following table shows the number of small plants identified.

Industry Subcategory	Number of Plants Incurring Costs	Number of Small Plants Incurring Costs	Number of Small Plants As a % of Total
Primary and Secondary Tin	5	3	60
Primary and Secondary Titanium	6	1	17
Primary Zirconium/Hafnium	2	1	50
Secondary Precious Metals	32	8	25
Secondary Tungsten/Cobalt	4	1	25

EPA guidelines on complying with the Regulatory Flexibility Act suggest several ways to determine what constitutes a significant impact on a substantial number of small businesses. Evaluation pursuant to these specific criteria are not required by the Regulatory Flexibility Act, nor suggested in the legislative history. However, the Agency is examining impact criteria beyond those used in its economic analysis in order to investigate fully whether this regulation could have a significant impact on small businesses. These additional criteria for the small business analysis are:

- Annual compliance costs as a percentage of revenues for small entities are at least 10% higher than annual compliance costs as a percentage of revenues for large entities, or
- Annual compliance costs increase total costs of production for small entities by more than 5%.

Table XXIV-1 presents a comparison of annual compliance costs as a percentage of revenues between small and large plants. In most instances, annual compliance costs as a percentage of revenues for small plants are more than 10% higher than the same ratio for large plants. Despite this difference between small and large plants, the ratios of compliance costs to revenues for small plants are quite low and thus indicate minimal impact. In the Primary and Secondary Titanium, Primary Zirconium/Hafnium, Secondary Precious Metals, and Secondary Tungsten/Cobalt subcategories, only one small plant, a secondary precious metals plant, is identified as a potential closure. Closure analysis identifies both large and small closure candidates in the Primary and Secondary Tin subcategory. Analysis of this ratio provides no clear indication of the relative magnitude of costs to small businesses.

Annual compliance costs as a percentage of total production costs has also been analyzed to determine the magnitude of impacts on small entities. The results of this analysis are presented in Table XXIV-2. In no instance does the ratio exceed the 5% threshold value used here as an indicator of significant impact on small businesses.

TABLE XXIV-1

ANNUAL COMPLIANCE COSTS AS
A PERCENT OF ANNUAL REVENUES
FOR LARGE AND SMALL PLANTS
(percent)

Subcategory	Option A	Option B	Option C
Primary and Secondary Tin			
Small	2.68	2.68	2.98
Large	1.82	1.82	1.93
Primary and Secondary Titanium			
Small	2.27	2.27	2.31
Large	0.26	0.27	0.30
Primary Zirconium/Hafnium			
Small	N/A ^a	N/A ^a	1.80
Large	2.07	2.07	2.12
Secondary Precious Metals			
Small	0.81	0.82	0.88
Large	0.09	0.09	0.10
Secondary Tungsten/Cobalt			
Small	0.73	0.73	1.16
Large	1.39	1.41	1.48

SOURCE: Policy Planning & Evaluation, Inc. estimates.

^aNot a treatment option.

TABLE XXIV-2

ANNUAL COMPLIANCE COSTS AS A PERCENT
OF TOTAL PRODUCTION COST
FOR SMALL PLANTS
(percent)

Subcategory	Option A	Option B	Option C
Primary and Secondary Tin	2.75	2.75	3.06
Primary and Secondary Titanium	2.65	2.65	2.70
Primary Zirconium/Hafnium	N/A ^a	N/A ^a	2.10
Secondary Precious Metals	1.02	1.03	1.11
Secondary Tungsten/Cobalt	0.85	0.85	1.35

SOURCE: Policy Planning & Evaluation, Inc. estimates.

^aNot a treatment option.

CHAPTER XXV

LIMITATIONS OF THE ANALYSIS

XXV. LIMITATIONS OF THE ANALYSIS

This chapter discusses the major limitations of the economic impact analysis. It focuses on the limitations of data and methodology and the key assumptions and estimations made in these areas.

A. DATA LIMITATIONS

Economic theory dictates that the financial health of the major impacted industries is determined by the volume of economic activity (e.g., value of shipments), capacity utilization, and prices. Economic analyses also generally distinguish between long-run and short-run effects. Decisions regarding variable costs, capacity, and relatively small amounts of resources are generally made on short-run criteria. On the other hand, decisions regarding large investment in fixed assets are made on the basis of long-run expectations.

In the absence of complete and current plant-specific financial data, a financial profile of the various metal industry segments plants was developed based on an extensive review of trade literature and published financial reports. This financial profile is subject to the following major assumptions and limitations:

- A "normal" or average year, in terms of aggregate economic conditions and financial performance, has been used as a baseline in the economic impact analysis. Therefore, estimates of price, capacity utilization, real durable goods sales, fixed investment, and total corporate profits have been based on the assumption that economic conditions in the impact period will be an average of conditions in the 1978-1982 business cycle. In general, due to adverse conditions in 1982, this implies that macroeconomic conditions during the impact period will be better than those in 1982.
- The industry capacity is assumed to be constant at 1982 levels. Industry sources indicate that firms are not contemplating any major expansions in capacity in the near future.
- Plant-specific economic variables have been estimated using financial ratio analysis. Financial information was obtained from the annual and 10-K reports of companies engaged in the smelting and refining of nonferrous metals. It was assumed that the financial characteristics of each plant could be approximated by the average financial characteristics of corporate segments operating in like industries. Hence, the financial characteristics of the plants were estimated by using corporate and segment information.

- The time value of money was taken into account by basing the analysis on constant prices and constant income. Current cost information presented in annual reports was utilized in order to create financial ratios consistent with this approach.

B. METHODOLOGY LIMITATION

Two types of performance measures have been used in the economic impact analysis:

- liquidity (short-term analysis); and
- solvency (long-term analysis).

The liquidity and solvency (net present value) measures are quite rough, primarily because of the lack of data. Industry-wide information has been used to analyze the firms in both the short term and the long term because the forecasting of firm-specific economic and institutional variables is extremely difficult. The analysis described here is not intended to be a structural specification of the profitability, liquidity, or solvency of the industries. Rather, it is designed to demonstrate that variations in the performance of the firms over time are likely to reflect general industry trends. The difference, if any, may be explained by a number of factors that were not explored in greater detail, such as capital-output ratios or technological and market changes.

C. SENSITIVITY ANALYSIS

Sensitivity analysis is used to determine whether variations in certain key factors significantly affect the results of the economic impact study. Several parameters of the study have been varied to assess the sensitivity of the study's results. The following paragraphs address the question of changes to the study's assumptions.

1. Monitoring Costs

A sensitivity analysis of monitoring costs was performed for each subcategory. For the original impact analysis, monitoring costs were based on the specific circumstances of each plant. For the sensitivity analysis, it was assumed that additional monitoring would be required. The results of the sensitivity analysis show that three additional closures would occur, in addition to the closures mentioned in Chapter XXII: one additional closure in each of the Primary and Secondary Titanium, Secondary Precious Metals, and Secondary Tantalum subcategories.

2. Changes in Production Process

Currently several plants engaged in the manufacture of germanium/gallium, titanium, and zirconium/hafnium utilize Level A processes. A sensitivity analysis was performed to determine the expected impacts if these plants change to level B processes. Only one zirconium/hafnium plant is projected to close if the plant changes from Level A to Level B processes.

If the existing discharger was identified as a Level B plant, a sensitivity analysis was not performed to determine the impacts of converting to Level A. This was not necessary, because Level A costs are less than Level B costs. For a more complete discussion of Level A and Level B production processes, see the Development Document.

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BIBLIOGRAPHY

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APPENDIX A

DESCRIPTION OF THE NPV TEST AND ITS SIMPLIFICATION

APPENDIX A

DESCRIPTION OF THE NPV TEST AND ITS SIMPLIFICATION

A. THE BASIC NPV TEST

The net present value test is based on the assumption that a company will continue to operate a plant if the cash flow from future operations is expected to exceed its current liquidation value. This assumption can be written mathematically as follows:

$$\sum_{t=1}^T U_t \left(\frac{1}{1+r}\right)^t + L_T \left(\frac{1}{1+r}\right)^T \geq L_0 \quad (1)$$

where: U_t = cash flow in year t

L_0 = current liquidation value

L_T = terminal liquidation value of the plant at the end of
a planning horizon of T years

r = cost of capital.

In order to use this formula, in this form, and in nominal dollars, forecasts of the terminal liquidation value (L_T) and income in every year during the planning period (U_t) have to be made. However, the need to make the forecasts can be avoided by using a simplified NPV formula, which is discussed in the following section.

B. SIMPLIFICATION OF THE NPV TEST

Equation (1) can be simplified by making the following three assumptions:

- o the equation considers real dollars, that is, the income, the liquidation value, and the rate of return are all expressed in real terms (see Section C for definitions);
- o $U_t = U_k = \bar{U}$, that is, real cash flows over the planning horizon are constant (or income in any given year is equal to the income in any other year); and
- o the current liquidation value is equal to the terminal liquidation value, that is, $L_T = L_0$.

Based on these assumptions, equation (1) can be rewritten as:

$$\sum_{t=1}^T \bar{U} \left(\frac{1}{(1+\bar{r})} \right)^t + \left(\frac{1}{(1+\bar{r})} \right)^T \bar{L}_0 \geq \bar{L}_0 \quad (2)$$

This expression can be simplified in the following manner. Let

$$k = \frac{1}{(1+\bar{r})},$$

Equation (2) may be written:

$$\left[\bar{U} \sum_{t=1}^T k^t \right] + k^T \bar{L}_0 \geq \bar{L}_0$$

Redefining the first bracket, and combining the two \bar{L}_0 terms:

$$\bar{U} \left[\sum_{t=1}^{\infty} k^t - \sum_{t=T+1}^{\infty} k^t \right] \geq \bar{L}_0 (1-k^T)$$

Using the expression for the sum of a geometric series,

$$\bar{U} \left[\frac{k}{(1-k)} - \frac{k^{T+1}}{(1-k)} \right] = \bar{U} \left[\frac{k}{(1-k)} \right] (1-k^T) \geq \bar{L}_0 (1-k^T);$$

$$\bar{U} \frac{k}{(1-k)} \geq \bar{L}_0;$$

$$\frac{\bar{U}}{\bar{r}} \geq \bar{L}_0;$$

$$\frac{\bar{U}}{\bar{L}_0} \geq \bar{r}. \quad (3)$$

Where: \bar{r} = real after-tax cost of capital

\bar{U} = real cash flow

\bar{L}_0 = current liquidation value in real terms.

These terms are defined in more detail in Section C below.

Equation (3) states that if the rate of return on the liquidation value (\bar{U}/\bar{L}_0) is greater than or equal to the real after-tax rate of return on assets, then the plant will continue in operation. Equation (3) is the same test as expressed in Equation (1), but is simpler to use. It does not require the forecasts of income and liquidation value.

The real rate of return on assets can be shown to be equal to the cost of capital. This relationship is explained in Section C. Thus, the methodology employed for the NPV test uses the rate of return on assets as a proxy for the cost of capital.

C. DISCUSSION OF REAL CASH FLOWS, COST OF CAPITAL, AND LIQUIDATION VALUE

1. Real Cash Flows

The difference between nominal cash flows and real cash flows is in the calculation of depreciation. While depreciation is calculated at book value for nominal cash flows, it is calculated at replacement value for real cash flows. In accordance with the definition of nominal cash flows used in Section II-G, real cash flows are as follows:

$$\begin{array}{rcll} \text{Real Cash} & & \text{All Operating Expenses} & \\ \text{Flows } (\bar{U}) & = & \text{Revenue} & - \text{Including Depreciation} & - \text{Taxes} \\ & & & \text{at Replacement Value} \end{array}$$

Normally, depreciation is not taken into account in calculating cash flows; however, it is included in the cash flow definitions. This inclusion means that a plant continuously maintains or replaces the capital equipment. The cost of maintaining and/or replacing equipment is equal to the depreciation. In order to calculate real cash flow, depreciation is taken at replacement value, not book value. Using this approach implies that the value of a plant's equipment remains constant, and therefore, the current liquidation value (L_0) is equal to the terminal liquidation value (L_T).

2. Real Cost of Capital

This report uses rate of return on assets as a substitute for cost of capital. However, the cost of capital can be shown to be equivalent to the rate of return on assets as follows. According to the Modigliani-Miller model (M-M model) the value of a leveraged firm is calculated by the formula:

$$V = \frac{X(1 - t)}{K_u} + (D)(t) \quad (1)$$

Where: V = value of the firm
 X = operating income before taxes
 t = tax rate
 K_u = cost of capital of an unleveraged firm
 D = debt.

The cost of capital of a leveraged firm in the M-M model is given by the formula:

$$K_L = K_u \left(1 - t \frac{D}{V}\right) \quad (2)$$

Where: K_L = cost of capital of a leveraged firm. By solving Equation (2) for K_u , we get

$$\therefore K_u = \frac{K_L}{\left(1 - t \frac{D}{V}\right)} \quad (3)$$

Using this value of K_u in equation (1), and simplifying, we get:

$$V = \frac{X(1 - t)\left(1 - t \frac{D}{V}\right)}{K_L} + (D)(t) \quad (4)$$

Dividing the whole equation by V , we get:

$$1 = \frac{X(1 - t)\left(1 - t \frac{D}{V}\right)}{VK_L} + \frac{(D)(t)}{V}$$

Therefore,

$$\therefore 1 - \frac{(D)(t)}{V} = \frac{X(1 - t)\left(1 - t \frac{D}{V}\right)}{VK_L}$$

$$\therefore 1 = \frac{X(1 - t)}{VK_L}$$

$$\therefore VK_L = X(1 - t)$$

or

$$K_L = \frac{X(1 - t)}{V} \quad (5)$$

Since the value of the firm = Equity + Debt = Assets, Equation (4) can be rewritten as:

$$K_L = \frac{X(1 - t)}{A}$$

Where: A = assets of the firm.

The equation above says that cost of capital to a leveraged firm (K_L) is equal to the after-tax rate of return on assets. The return on assets for a firm or a group of firms can be calculated by using information from financial statements. For the purposes of this report the real rate of return is calculated as follows:

$$\text{The real rate of return } (\bar{r}) = \frac{\text{real cash flows } (U)}{\text{total assets at replacement value}}$$

APPENDIX B

IMPLEMENTATION OF THE NPV TEST

APPENDIX B
IMPLEMENTATION OF THE NPV TEST

A. PRIMARY PROBLEM IN IMPLEMENTING THE TEST

The NPV formula reduces to the following equation:

$$\frac{\bar{U}}{\bar{L}_0} \geq \bar{r}.$$

If there were no limitations to the availability of plant-specific financial data, the values of these three variables could be calculated for each plant. The data collected in the Agency's survey of the industry, however, is limited with respect to current financial and cost information. Information on income, depreciation, capital expenditures, cost of capital and future sales are needed to carry out the NPV test; hence, it must be estimated for each plant from publicly available information.

The nonferrous Phase II metals industry consists of more than 200 plants. The task of estimating the data for each plant is simplified by:

- classifying the nonferrous metals industry into eight groups;
- estimating the values of ratios such as: operating income/sales, operating income/assets, current assets/sales, non-current assets/sales, and capital expenditure/sales for each of the eight groups; and
- classifying a plant into one of the eight groups, and applying the ratios associated with the group to the plant.

B. ORGANIZATION OF THIS APPENDIX

Section C below describes the method used to classify the industry into eight groups, defines the groups, and describes the applicability to the specific metals covered in this report. Section D discusses the procedure used to calculate group ratios. Section E presents the method used to estimate sales of each plant, and Section F discusses the methods used to estimate operating income, current assets, fixed assets, capital expenditures, and the liquidation value of each plant. Section G summarizes the earlier sections with an overview of the NPV test.

C. DEVELOPMENT OF GROUPS AND APPLICATION TO METALS

1. Definition of Groups

The eight groups were formed by using the following steps:

- The annual and 10K reports of 30 companies engaged in the production of nonferrous metals were obtained.
- Most annual and 10K reports provide financial information pertaining to major lines of business (business segment information). The 30 annual reports contained data on 40 business segments. (Some companies had more than one line of nonferrous metal business.)
- These 40 business segments were classified into eight relatively homogenous groups by examining qualitative descriptions of business segments, and by calculating average group ratios and evaluating the differences among groups.

Data for the years 1980, 1981, and 1982 were used to establish the eight groups. These groups, representing similar business and financial characteristics, are as follows:

- Group 1: Smelting and Refining of Primary Base Metals -- This group includes the mining, smelting, and refining of primary base metals, such as copper, lead, zinc, and aluminum. Many large-scale companies such as Asarco, Alcoa, and Amax are primarily engaged in the production of such metals.
- Group 2. Smelting and Refining of Precious Metals -- Four companies have concentrated their operational activities in the mining, smelting, and refining of precious metals such as gold, silver, and platinum.
- Group 3. Smelting and Refining of Other Nonferrous Metals (not included in Groups I and II) -- About six companies are engaged in the mining, smelting, and refining of other metals, such as lithium, molybdenum, columbium, tungsten, zirconium, beryllium, nickel, cobalt, and chrome. Such metals generally have anti-wear, anti-corrosion characteristics. They also enhance the toughness and strength of ferrous-based alloys.
- Group 4. Reclamation of Precious and Semi-Precious Metals -- Reclamation of such metals from scrap, jewelry, and electronic components is being undertaken on a large scale by various companies such as Handy and Harman, Refinemet Corporation, and Diversified Industries, Inc. The value of shipments of reclaimed metals is a significant portion of shipments for these companies.

- Group 5. Smelting and Refining for Producing Alloys -- Mining, smelting, and refining for the purpose of producing alloys is an important segment for many companies, including Foote-Mineral Co., Cabot Corporation, and Hanna Mining Co. These products include ferro-alloys, tantalum alloys, columbium alloys, and nickel alloys. Reclamation of alloys from metal scrap is also included in this segment because it constitutes a significant part of business operations for these companies.
- Group 6. Reclamation of Base and Other Nonferrous Metals -- In addition to producing metals such as copper, aluminum, and zinc from their respective ores, companies may also reclaim these metals from scrap, junked automobiles and electronic appliances. This group covers reclamation activities for these and other nonferrous metals.
- Group 7. Production of Metal Products, Alloys, and Metal Powders -- The combination of metal products, alloys, and metal powders is considered one segment. It does not involve any mining or recycling. Companies engaged in such production purchase raw materials to manufacture such items.
- Group 8. Production of Rare-Earth Metals -- Rare-earth metals have special characteristics of their own. They improve many common items; for example, some help polish glass, decolor it, or tint it, and others filter out or absorb light rays. Examples of such metals are mischmetal, cerium, lanthanum, and didymium. Because of these special characteristics, the production of rare-earth metals has been taken as a separate segment.

2. Application of Groups to Subcategories

Twenty-one metal subcategories are included in the economic analysis. The plants in these subcategories are evaluated with financial ratios from the groups defined above. The assignment of plants to specific groups is based on business considerations. The following list identifies the assignments.

<u>Subcategory</u>	<u>Group Used for Financial Ratios</u>
Primary Antimony	Group 3
Bauxite Refining	Group 1
Primary Beryllium	Group 3
Primary Boron	Group 7
Primary Cesium/Rubidium	Group 7
Primary and Secondary Germanium/Gallium	Group 7
Secondary Indium	Group 7
Secondary Mercury	Group 6
Primary Molybdenum/Rhenium	Groups 3 and 7
Secondary Molybdenum/Vanadium	Group 5
Primary Nickel/Cobalt	Group 3
Secondary Nickel	Group 5
Primary Precious Metals/ Mercury	Group 2
Secondary Precious Metals	Group 4
Primary Rare-Earth Metals	Group 8
Secondary Tantalum	Group 6
Primary and Secondary Tin	Group 6
Primary and Secondary Titanium	Groups 3 and 7
Secondary Tungsten/Cobalt	Group 7
Secondary Uranium	Group 7
Primary Zirconium/Hafnium	Group 7

D. PROCEDURE FOR CALCULATING GROUP RATIOS

Each of the eight groups defined above is comprised of several business segments. Group financial ratios are calculated as follows:

- calculate financial ratios for each segment within the group over several years; and
- average segment ratios over all segments and all years.

The details of the calculations for each group ratio are presented below. The results of these calculations (the group ratios) are shown in Table B-1, at the end of this appendix.

1. Calculation of Operating Income/Sales

$$\frac{\bar{U}_g}{S_g} = \frac{\text{real cash flow of group } g}{\text{sales of group } g}$$

$$\frac{\bar{U}_g}{S_g} = \frac{1}{T} \sum_{t=1}^T \frac{1}{M} \sum_{m=1}^M \frac{\bar{U}_{m,g,t}}{S_{m,g,t}}$$

Where: $\bar{U}_{m,g,t}$ = real cash flow of segment m in group g in year t (calculated from business segment information of annual reports).

$S_{m,g,t}$ = sales of segment m in group g in year t (given in business segment information of annual reports).

M = number of segments in group g .

t = 1978, 1979, 1980, 1981, 1982.

2. Operating Income/Assets (Real Cost of Capital)

$$\bar{r}_g = \frac{\bar{U}_g}{A(\text{adj})_g} = \frac{\text{real cash flow of group } g}{\text{adjusted assets of group } g}$$

$$\bar{r}_g = \frac{\bar{U}_g}{A(\text{adj})_g} = \frac{1}{T} \sum_{t=1}^T \frac{1}{M} \sum_{m=1}^M \frac{\bar{U}_{m,g,t}}{A(\text{adj})_{m,g,t}}$$

Where: $A(\text{adj})_{m,g,t}$ = adjusted value of assets of segment m in group g in year t .

$$A(\text{adj})_{m,g,t} = A_{m,g,t} \cdot (1+x)$$

Where:

$$(1+x) = \frac{\text{current costs}}{\text{historical costs}} = \frac{1}{h} \sum_1^h \left(\frac{\text{depreciation at replacement value in 1982}}{\text{depreciation at book value in 1982}} \right)$$

h = Number of companies in the data base.

$A_{m,g,t}$ is obtained from business segment information contained in annual reports.

3. Current Assets/Sales

$$\frac{(CA)_g}{S_g} = \frac{\text{current assets of group } g}{\text{sales of group } g}$$

$$\frac{(CA)_g}{S_g} = \frac{1}{T} \sum_{t=1}^T \frac{1}{M} \sum_{m=1}^M \frac{(CA)_{m,g,t}}{S_{m,g,t}}$$

Where: $(CA)_{m,g,t}$ = current assets of segment m in group g in year t .

The business segment information contained in corporate annual reports does not give any information on current assets of the segments. Therefore, current assets of the segments have been estimated based on the characteristics of the company to which they belong.

$$(CA)_{m,g,t} = \left[\frac{(CA)_{c,g,t}}{S_{c,g,t}} \right] S_{m,g,t}$$

Where: $(CA)_{c,g,t}$ = current assets of the company c (to which the segment m belongs) in group g in year t.

$S_{c,g,t}$ = sales of company c (to which the segment m belongs) in group g in year t.

$S_{m,g,t}$ = sales of segment m of company c in group g in year t.

4. Non-Current Assets/Sales

$$\frac{(BV)_g}{S_g} = \frac{\text{book value of plant and equipment of group g}}{\text{sales of group g}}$$

$$\frac{(BV)_g}{S_g} = \frac{1}{T} \sum_{t=1}^T \frac{1}{M} \sum_{M=1}^M \frac{(BV)_{m,g,t}}{S_{m,g,t}}$$

Where: $(BV)_{m,g,t}$ = book value of segment m in group g in year t.

The business segment information contained in annual reports of companies does not give information on book values of plant and equipment of segments. Hence, they have been estimated by the same method used for estimating current assets of segments.

$$(BV)_{m,g,t} = \left[\frac{(BV)_{c,g,t}}{S_{c,g,t}} \right] S_{m,g,t}$$

Where: $(BV)_{c,g,t}$ = book value of the company c (to which the segment m belongs) in group g in year t.

5. Capital Expenditure/Sales

$$\frac{(CE)_g}{S_g} = \frac{\text{capital expenditures of group g}}{\text{Sales of group g}}$$

$$\frac{(CE)_g}{S_g} = \frac{1}{T} \sum_{t=1}^T \frac{1}{M} \sum_{M=1}^M \frac{(CE)_{m,g,t}}{S_{m,g,t}}$$

Where: $(CE)_{m,g,t}$ = capital expenditures of segment m in group g in year t. (Provided for each business segment in corporate annual reports.)

E. ESTIMATION OF ANNUAL REVENUES (SALES) OF EACH PLANT

$S_{i,g,D}$ = sales of plant i in group g in the year D

$$S_{i,g,D} = \left[C_{i,1982} \times (CU)_i \right] \cdot P_I$$

Where: $C_{i,1982}$ = Capacity of plant i in 1982 (assumed to be the same in 1985).

$(CU)_i$ = Average capacity utilization of plant i belonging to industry I between 1978 and 1982.

P_I = Average real (inflation adjusted) price of metal in industry I under between 1978 and 1982.

The above equation simply states that capacity multiplied by capacity utilization, which equals production, multiplied by price equals sales.

F. ESTIMATION OF PLANT LEVEL OPERATING INCOME, CURRENT ASSETS, PLANT AND EQUIPMENT, CAPITAL EXPENDITURES, AND LIQUIDATION VALUE

It is assumed that each plant possesses the characteristics of the group in which it falls. Hence, group ratios are used to estimate plant-level variables. The values of most of these variables are calculated by multiplying a group ratio (as defined in Section D above) by the plant's sales (Section E above).

1. Calculation of Operating Income of Plants

$\bar{U}_{i_g,D}$ = real cash flow of plant i in group g in the year D.

$$\bar{U}_{i_g,D} = S_{i_g,D} \times \frac{\bar{U}_g}{S_g}$$

2. Calculation of Current Assets of Plants

$(CA)_{i_g,D}$ = current assets of plant i in group g in the year D.

$$(CA)_{i_g,D} = S_{i_g,D} \times \frac{(CA)_g}{S_g}$$

3. Calculation of Plant and Equipment of Plants

$(BVadj)_{i_g,D}$ = adjusted book value of plant and equipment of plant i in group g in the year D.

$$(BVadj)_{i_g,D} = (BV)_{i_g,D} \times (1+x)$$

where $(1+x) = \frac{\text{current costs}}{\text{historical costs}}$

$$(BV)_{i_g,D} = S_{i_g,D} \times \frac{(BV)_g}{S_g}$$

4. Calculation of Capital Expenditures of Plants

$(CE)_{i_g,D}$ = capital expenditures of plant i in group g in the period D .

$$(CE)_{i_g,D} = S_{i_g,D} \times \frac{(CE)_g}{S_g}$$

5. Calculation of Liquidation Value

$\bar{L}_{o_{i_g},D}$ = real liquidation value of plant i in group g in period D .

Under the assumption that plant and equipment have no scrap value except as a tax write-off (a common practice in the industry), the liquidation value is calculated as follows:

$$\bar{L}_{o_{i_g},D} = 0.7(CA)_{i_g,D} + t (BV)_{i_g,D}$$

Where: t = tax rate.

Only a portion of the value for current assets is included in the liquidation value because only a certain amount can be recovered when the plant is liquidated. Financial literature suggests this portion to be approximately 70 percent of current assets.

Neither short-term nor long-term liabilities are taken into account while calculating the liquidation value of plants, because they do not affect the plant closure decisions. Whether the plant is closed or is kept operating, liabilities will have to be paid, and so they are not crucial decision factors in plant-closure analysis.

G. IMPLEMENTATION OF NPV TEST

The general form of the NPV test is

$$\frac{\bar{U}}{\bar{L}_o} \geq \bar{r}$$

In order to implement the NPV test, the annual compliance cost must be subtracted from the real cash flow of the plant. Thus, the NPV test for each plant can be written as:

$$\frac{\bar{U}_{i_g,D(\text{adj})}}{\bar{L}_{o_{i_g,D}}} \geq \bar{r}_g$$

where

$$\bar{U}_{i_g,D(\text{adj})} = \bar{U}_{i_g,D} - (\text{Total Annual Cost})_i$$

$$\bar{L}_{o_{i_g,D}} = \text{liquidation value of plant } i \text{ (defined above in Section F.5)}$$

$$\bar{r}_g = \text{real cost of capital for group } g \text{ (defined above in Section D.2)}$$

The procedure for calculating total annual cost is explained in Appendix C.

TABLE B-1

Group No.	Real Cost of Capital (F)	Operating Income to Sales (u/s)	Cap. Exp. to Sales (CE/S)	Non-Current to Sales (Br/S)	Current Assets to Sales (CA/S)
1	.1014	.0740	.1188	.5430	.4187
2	.2562	.2993	.1036	.4521	.5265
3	.1725	.2064	.1415	.4781	.4373
4	.2069	.0936	.0100	.0717	.3988
5	.1669	.0848	.0452	.2075	.3510
6	.0404	.0274	.0328	.1644	.3217
7	.1466	.1430	.0906	.2881	.4507
8	.1187	.0884	.3890	.3396	.4362

APPENDIX C

CALCULATION OF TOTAL ANNUAL COSTS
FOR THE TWO CLOSURE ANALYSIS TESTS

APPENDIX C

CALCULATION OF TOTAL ANNUAL COSTS FOR THE TWO CLOSURE ANALYSIS TESTS

Both the Net Present Value test (NPV test) and the liquidity test deduct the incremental compliance costs from revenues (operating income). While the NPV test judges the firm from the long-term point of view, the liquidity test appraises the short-term viability of the firm. The incurrence of pollution control expenditures, therefore, calls for an adjustment to the real cash flows discussed in Appendix A. The additional costs result in annual cash outflows -- as a result of increased operating costs, maintenance expenditures, and payments for the initial capital outlay. However, these costs also result in some tax benefits, as taxable income is determined after the deduction of both operating and depreciation expenditures. The firms also benefit from the Investment Tax Credit (ITC). For purposes of estimating the pollution control costs for the two tests, all tax benefits must be considered.

A. CALCULATION OF TAX BENEFITS DUE TO INCREASED DEPRECIATION

Since depreciation is an allowable expense for tax purposes, it has the effect of reducing taxes. If the tax rate is assumed to be t and depreciation is D , taxes decrease by $(t)(D)$ every year. The tax savings are in nominal dollars; hence, the present value of the tax benefits must be calculated by discounting the nominal tax savings by the nominal rate of return.

The depreciation tax benefit in year $k = t(D_k)$

Where: $D_k = d_k \times 0.95P^1$

d_k = depreciation rate in year k

P = capital cost to the plant.

The present value of the depreciation tax shelter =

$$\sum_{k=1}^K \frac{t(D_k)}{[(1+r)(1+g)]^k}$$

¹In accordance with the terms of the Tax Equity and Fiscal Responsibility Act of 1982, only 95% of the capital costs can be depreciated. Thus, the amount P , which is the initial capital cost, is adjusted to 95 percent of its value.

Where: r = real cost of capital (as defined in Appendix B, Section D.2;
this value varies by group)

g = inflation rate (assumed to be 6 percent)

K = taxable life of the asset.

The capital expenditures required to install the necessary treatment equipment have been depreciated over the taxable life of five years. In accordance with the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA), capital equipment can be depreciated as follows.

- 1) 15% of the depreciable assets (95% of P) equals the depreciation in the first year.
- 2) The remaining portion of the asset (85%) is depreciated on a straight-line basis over the remaining four years. In this study, the depreciation rates are taken to be 22% for the second year and 21% for each of the last three years.

B. CALCULATION OF EFFECTIVE CAPITAL COST (NPV TEST)

The effective capital cost is calculated after the deduction of the following items from the capital costs of pollution control equipment:

- 1) Investment tax credit (ITC), which in accordance with TEFRA equals 10% of capital costs;
- 2) Present value of depreciation and interest tax shelters.

$$\sum_{k=1}^5 tD_k \times \frac{1}{[(1+r)(1+g)]^k}$$

Therefore,

$$\text{Effective Capital Cost} = \left\{ P - 0.1P - \sum_{k=1}^5 tD_k \times \frac{1}{(1+r)(1+g)^k} \right\}$$

C. CALCULATION OF ANNUALIZED CAPITAL COSTS (NPV TEST)

The effective capital expenditures are amortized over the useful lifetime of the asset to obtain annualized capital costs as follows:

$$\text{The annualized capital costs (ACC)} = \left\{ 0.9P - \sum_{k=1}^5 tD_k \times - \frac{1}{(1+\bar{r})(1+g)^k} \right\} \times \frac{\bar{r}(1+\bar{r})^n}{(1+\bar{r})^n - 1}$$

where $n = 10$ = the assumed lifetime of the equipment.

Note that the annualized capital cost ACC is the product of the effective capital cost and a capital recovery factor

$$\frac{\bar{r}(1+\bar{r})^n}{(1+\bar{r})^n - 1}$$

D. CALCULATION OF TOTAL ANNUAL COSTS (NPV TEST)

The annual pollution control expenditures (APC_p) are calculated as follows:

$$APC_p = ACC + (1-t)AAC$$

Where: ACC = annualized capital cost (see Section C)

AAC = annual operating costs. The term $(1-t)$ takes into account the tax effect of increased expenses.

E. THE NPV TEST

The NPV test, which now takes into account the pollution control expenditures, can now be stated as follows:

If,

$$\frac{\bar{U} - APC_p}{L_o} \geq \bar{r}$$

Then, a plant will continue in operation.

F. CALCULATION OF ANNUAL POLLUTION CONTROL EXPENDITURES
(LIQUIDITY TEST)

The liquidity test is designed to measure the short-term solvency of the firm. The basic premise of this analysis is that a plant will close if pollution control expenditures cause negative cash flows in the foreseeable future. The cash flows are defined as earnings after all operating expenses (including depreciation), interest, and taxes.

The effective capital cost is, therefore, amortized over a shorter period of five years. The annualized capital cost (ACC_q) in this case is

$$\left\{ 0.9P - \sum_{k=1}^5 tD_k \times \frac{1}{[(1+\bar{r})(1+g)]^k} \right\} \frac{\bar{r}(1+\bar{r})^5}{(1+\bar{r})^5 - 1}$$

Total annual pollution control expenditures (APC_q) in the case of the liquidity test are, therefore, greater than in the case of the NPV test.

G. THE LIQUIDITY TEST

The liquidity test can now be stated as follows:

If,

$$\bar{U} - APC_q \leq 0$$

Then, the plant will close.

APPENDIX D

PROCEDURE FOR CALCULATING INDUSTRY-WIDE IMPACTS

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PROCEDURE FOR CALCULATING INDUSTRY-WIDE IMPACTS

This appendix briefly details the procedures followed in computing certain ratios used to analyze industry-wide impacts. These impacts concern: (1) changes in production costs; (2) price changes; (3) changes in return on investment; and (4) effects on capital expenditures.

A. CHANGES IN PRODUCTION COSTS

$$\text{Changes in production costs} = \frac{\sum_{i=1}^n (\text{APC}_i)}{\sum_{i=1}^n (S_i - \bar{U}_i)}$$

Where: APC_i = annual pollution control expenditures of plant i

S_i = annual sales of plant i

\bar{U}_i = real income of plant i

n = number of plants in subcategory

B. PRICE CHANGES

$$\text{Changes in price} = \frac{\sum_{i=1}^n \text{APC}_i}{\sum_{i=1}^n S_i}$$

Where: APC_i = annual pollution control expenditures of plant i

S_i = annual sales of plant i

n = number of plants in subcategory

C. CHANGES IN RETURN ON INVESTMENT

$$\text{Changes in return on investment} = \frac{(\bar{r}' - \bar{r})}{\bar{r}}$$

Where: \bar{r} = precompliance real rate of return for each subcategory, as defined in Appendix A.

\bar{r}' = postcompliance real rate of return for each subcategory

\bar{r}' is computed as follows:

$$\bar{r}' = \frac{\sum_{i=1}^n (\bar{U}_i - \text{APC}_i)}{\sum_{i=1}^n (A_i + \text{CC}_i)}$$

Where: \bar{U}_i = real income of plant i

APC_i = annual pollution control expenditures of plant i

A_i = assets of plant i, which equal \bar{U}_i / \bar{r}

CC_i = pollution control capital costs of plant i

n = number of plants in subcategory

D. EFFECTS ON CAPITAL EXPENDITURES

$$\text{Effects on capital expenditures} = \frac{\sum_{i=1}^n \text{CC}_i}{\sum_{i=1}^n \text{CE}_i}$$

Where: CC_i = pollution control capital costs of plant i

CE_i = estimated capital expenditure budget of plant i

n = number of plants in subcategory